UNITED STATES DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

An Evaluation of Research on Fire and Smolder Retardant Cotton Products

October, 1975

Southern Regional Research Center
New Orleans, Louisiana 70179

ADDENDUM

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Page 18---end of paragraph, add:

(Crikelair, M.D., George F., "A Win For the Team," Proceedings of the Ninth Annual Meeting, Information Council on Fabric Flammability, New York City, December 11, 1975.)

Page H-1---after 7th line, add the same reference.

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Executive Summary

The Southern Regional Research Center textile fire retardant research program was initiated to reduce fire hazards to people. During the time frame of evaluation, 1964-1973, its gross cost has been $8.4 million. It is estimated that industry, foundations, and other government agencies have spent $25 million for closely related research during the same time period.

The results of the ARS research in this field as measured in terms of new knowledge, the immediate products of research, are:

146	technical publications
54	patents issued, 23 patents applied for and still pending
100	significant technical accomplishments
10	commercialized products[1/]
171	technical presentations
12,290	requests for technical information[2/]
96	in-plant technical consultations
197	visitor consultations (man days)
1,361	letter and telephone consultations
10,636	laboratory visitors

The impact of the above accomplishments on the people of the world, even the United States with its extensive record keeping, is very difficult to determine because of its nature--the effects of accidents that do not happen; i.e., the effects on people of cotton textile fires that were averted because of applying the new knowledge

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1/ Net economic activity based on these is $15.7 million for 1973 with a potential annual saving of $51.8 million.

2/ The total investment on the part of those served by these consultations has been $1.2 million.

generated by this research. Despite this difficulty there are some data available that, appropriately manipulated, may serve as a lower bound indicator of the primary impact of the program. These would seem to indicate that there is a significant reduction in the seriousness and fatalities due to burns:

--to children, wearing flame retardant sleepwear,

--to working adults, using flame retardant work clothes,

--to the military, through the use of fire retardant tent liners, and special uniforms, and,

--to the public in general, because of the introduction of flame retardant mattresses and tentage but more importantly because of the public educational program that resulted as a spin-off from this research.

In actual dollar value, the cost of the ARS fire retardant research program is computed at $8.4 million over a ten year period and benefits based on 13 known cases in the one year 1973 is $17.8 million. Potential benefits are estimated at $51.8 million annually. No monetary estimate was made of savings to the military, industrial workers, or to civilians from safer tentage because a reliable data base does not exist. The monetary value placed on the saving of a human life is still controversial and is in the arena of theoretical economics.

AN EVALUATION OF RESEARCH ON FIRE AND SMOLDER RETARDANT COTTON PRODUCTS

Introduction

Departments and agencies of government are funded to carry out specified operations and functions judged to be in the public interest. The effectiveness and efficiency with which such missions are discharged are a legitimate concern of the public and their elected and appointed representatives. The President's Office of Management and Budget has directed that federal departments and agencies provide for continuing systematic review of all aspects of program management, including the evaluation of program effectiveness in accomplishing program objectives.

The Department of Agriculture has established a program evaluation function administered in the Office of Management and Finance to assure that such evaluations are carried out. In guidelines to the agencies the Department has defined program evaluation as the ex post facto evaluation of the effectiveness of ongoing programs in meeting the USDA missions and goals, achieving program objectives, and serving specified target groups. The purpose of this paper is to report the evaluation of a definable segment of ongoing ARS research--that conducted during the period 1964-73 on imparting better flame and smolder retardancy to cotton products.

Rationale

Far more textile fires have fatal consequences than is generally supposed. Lack of public protest is understandable because, until now, people have accepted as inevitable the ignitability and flammability of apparel and furnishing fabrics and batting. Moreover, deaths and injuries due to textile fires were not recorded as such but often incorporated in other statistics. It is only in the past few years that such accidents and their causes have been reported objectively and in depth.

Recognizing the need to alleviate the problem of burns due to textiles and that a gap existed in research in this area, the Southern Regional Research Center initiated a pioneering research program to develop fire retardant cotton products.

Time Frame and Program Objectives

The time frame for this evaluation is 1964 through 1973 and is for the Research and Development Program on Fire and Smolder Retardant Cotton Products. The time frame was selected for two reasons: (1) data availability and applicability, and (2) the need for a span of years to

reflect an overall progress track. The nature and application of scientific research results are such that the benefits begin to become evident only over a significant period of years.

Research on fire retardant cotton products is classified in the Department Program Structure as follows:

USDA Mission No. 5 - Consumer Services and Human Resource Development--which has the broad social goal of improving services to, and protecting the health of, people and has the specific operating goal next named.

Operating Goal No. 2 - New Knowledge to Reduce Health Hazards and Improve Family Living--which has, among others, the specific program objective of developing knowledge needed by farmers, processors, distributors, consumers, and by government agencies to reduce hazards to health and safety.

Program Element No. 648 - Research to Improve Human Health, and Safety.

Research Activity No. 14560 - Fire Retardant Cotton Products.

The program objectives over the entire time frame are detailed in Appendix A-1 through A-5.

Briefly summarized, the objectives over the years may be stated in the form of product specifications. Although the specifications have changed rapidly during the past ten years to realistically reflect the rapid changes that have taken place with legislation, standards, and technical innovations, they may be broadly stated as to develop commercially acceptable textile flame-retardant and smolder-resistant products which are:

(1) durable;

(2) efficient and low cost;

(3) least detrimental in aesthetic, chemical and physical properties;

(4) safe; and,

(5) impart other desirable properties such as abrasion and crease resistance.

It is recognized that no single treatment will be universally applicable to all end-use products, nor will any single treatment meet all specifications optimally.

As an example, in relation to improvements in end-product property performance, where fancy jersey knits are concerned, the important properties of bursting strength and softness have been improved 14% and 20% respectively; napped sheeting, which is difficult to flame retard because of its physical construction, was improved in char length and oxygen index tests by more than 80%; cotton flannelette for children's sleepwear, the vital textile in the present standards, showed significant overall property improvement as measured by char length, breaking strength, tearing strength, wrinkle recovery and stiffness--these properties are important also in apparel, and will form the base on which flame-retardant apparel fabrics are being developed to meet projected standards. Examples of property improvement data appears in Appendix A-6 through A-8.

Cotton batting, in reality, started from a zero-base in properties. Resilience was virtually nonexistant until the development of the SRRC "cotton flote" product. In the span of a few years, the "cotton flote" product attained properties of afterglow, afterflame and permanence to meet federal, state and commercial mattress and automotive use flammability standards.

The standards for wearing apparel revolve around flaming; those around batting are entirely different in that afterglow and afterflame play a more serious role.

In addition to product performance, the following social and economic goals are sought:

(1) Save lives, prevent disability, and reduce debility--safer cotton products.

(2) Contribute to health and safety education--increase perception of the general public to the danger of fires.

(3) Comply with the interest of Congress as provided by the Flammable Fabrics Act and the Automobile Safety Act.

(4) Maintain and expand cotton markets.

(5) Provide cotton batting products having greater net added value and a better price advantage over competetive materials.

(6) Strengthen market for cotton lint and linters to improved farm income from the cotton crop.

(7) Increase consumption of flame-retardant chemicals such as Thpc which is a by-product in chemical manufacturing.

(8) Establish a technological base for the development of a new industry oriented toward supplying small batting manufacturers with flame-retardant treated raw stock.

Statistics on Textile Fires

Comprehensive and detailed domestic and worldwide statistics are not yet available, although it is claimed that every hour, at least one person is being killed, injured, maimed or mutilated because his clothing or other textiles caught fire.

The U.K. Home Office Working Party on Flammable Clothing estimated that clothing fires kill 250 people annually in Great Britain. In Switzerland, based on carefully documented hospital records, it is estimated that the mortality rate for patients whose injuries were due exclusively to burning apparel was 42.9% or, 150 fatalities per year in a population of 6 million.

In the United States, total deaths caused by fires in 1973, are estimated at 11,900 and 6,500 of these are attributable to combustible materials. Total property value of fire losses are over $3.0 billion. Actual number of burn cases directly related to textile fabrics ignition over a seven year period is reported as 3,748. During the period 1966-73, cumulative cases in age group 0-6 years involving nightwear as the first fabric to ignite was 81.

It is quite apparent that voluminous data is being accumulated on the seriousness of death and injury that is associated or directly attributable to textiles. However, no unified model has been developed for the collection of such data. Most of the difficulty appears to be in the subjective evaluation concerning the cause of the accident, viz. cigarette vs. mattress. Further, in attempting to determine the cost effectiveness of the 0-6X flammability standard, it is difficult to collect data on accidents that did not happen, the children who did not get burned or whose burns or other injuries were considerably lessened by the flame retardancy of the sleepwear being worn. This situation prompted the Information Council on Fabric Flammability to formally request the Consumer Product Safety Commission (CPSC) to undertake such a study. CPSC responded that they have "begun planning a comphrensive program to develop, in part, evaluations of its regulatory activities."

Source of the more relevant data on statistics gathering appears in Appendix B-1 through B-10.

Limitation of Data

Many commercial sources (chemical manufacturers, textile finishers, etc.) consider such information as plant capacity for the production of Thpc, yardages finished by a specific flame retardant process, as proprietary information. This is understandable. Hence, such information is not available directly but can be estimated closely by experts from trade organizations such as the National Cotton Council of America.

One other aspect of benefits that cannot be estimated includes the addition to the GNP of private dollars into commercialization of fire retardant processes invented at the Southern Regional Research Center. It is evident that the host of firms selling Thpc finishes required a research and development effort to individualize their brand of product. Therefore, "added value" benefits are somewhat limited.

The benefits of the Thpc-amide finish, as related to fire losses do not appear in the tabulations because no model or system for collection of such data is available. Only such vague accounts of independent claims of the Washington Fire Department appear from time to time (Appendix C-1). The Thpc-amide finish was in commercial production about 1965 by the Lynrus Finishing Company. This fabric was used to produce garments for workers exposed to flames such as firemen, welders, metallurgical processes, etc. Savings due to minimizing accidental burns in these industries are not available and no attempt to gather such information are contemplated.

The Thpc-amide finish was used on military tent liners in addition to the standard FWWMR treatment for the tent itself. However, the effectiveness in limiting injury and death is not known for the added protection afforded by the tent liner. Some basic data is available for tentage during a period when flame retardant tent liners were not used and for non-combat zones. This data shows that aside from economic losses, injuries to people do occur even in a highly structured environment (Appendix C-2).

No real data is available on civilian tent fires, its relationship to human safety or possible contributions to forest fires. One study indicates 75 tent fires over the period 1948-1974 and extrapolates this number to a total of 320, based on state averages, or 1200 based on population (Appendix C-3).

Various organizations NBS, CPSC, HEW, National Burn Information Exchange, Shriners Burns Institute, National Fire Protection Association, National Insurance Acturial and Statistical Association, attempt to gather burn and injury statistics. A typical comment on one study applies to all such studies: "This survey represents a significant contribution to the measurement of national fire incidence; however, one must be careful to recognize the limitations of the data. Although the sample size of 33,000 households is large, the occurrence of a fire is a rare event, statistically. Therefore, although we may have confidence in the precision of estimates of large totals, such as the total number of fires, when we estimate sub-totals, such as fires involving a given product or a given room in a house, the precision is sharply degraded.

In terms of injury data, the precision of this survey is much lower, since a fire-related injury is a rare event among rare events. Unfortunately, a survey of this size does not permit accurate estimation of injuries. One must be satisfied with fair precision in estimating total injuries, and not lend inappropriate credibility to estimates of subcategories." (Buchbinder and Mathers, "Preliminary Indications from Survey of U.S. Household Fire Experience," presented at the 8th Annual Meeting Information Council on Fabric Flammability, New York, December 5, 1974.)

Furthermore, textile fire injury cases are difficult to cross-reference because of their uniqueness relative to circumstances, environmental setting, randomness and the use of diverse reporting format. Such cross-references lead to widely divergent estimates (example: 11,000 deaths attributable to fires vs. 45,000 estimated from another study by indirect calculation--it is normally assumed that death data could factually represent absolute numbers and would not vary so drastically--but this is not the case in burn studies).

Legislation

The U.S. was the first country to pass legislation limiting the sale of highly flammable textiles. Other countries followed with standards and tests to keep the ignitability and flammability of textiles within certain limits. No country has yet introduced comprehensive fire laws or regulations that compel all manufacturers or retailers to label all highly flammable fabrics.

Because of increased public awareness of the national and local need, textile fire retardant research and development are embodied in both federal, state, and local legislation. Included in the legislation are regulations, standards, and compliance procedures that impact on research, production, distribution, and final uses of natural and manmade textile materials.

The Flammable Fabrics Act was enacted in 1953 by the United States Congress "to prohibit the introduction or movement in interstate commerce of articles of wearing apparel and fabrics which are so highly flammable as to be dangerous when worn by individuals, and for other purposes." It requires all fabrics and apparel to comply with Commercial Standard 191-53 (CS191-53), "Flammability of Clothing Textiles."

In 1967 the Flammable Fabrics Act was amended, giving the Secretary of Commerce broader authority in the promulgation of specific standards when found to be in the public interest, extending coverage of the Act to interior furnishings (for home, office, and other places of assembly or accommodation) and defining "related materials" to include paper,

plastic, rubber, and synthetic film, or investigate possible needs for more explicit standards dealing with various uses of textiles. This authority has resulted in the following federal standards in apparel and textile home furnishings:

Standard Designation	End Use Affected
FF 1-70	Large Carpets & Rugs
FF 2-70	Small Carpets & Rugs
FF 3-71	Children's Sleepwear, Sizes 0-6X
FF 4-72	Mattresses
FF 5-74	Children's Sleepwear, Sizes 7-14

Although initial legislation enpowered the Secretary of Commerce to write needed standards, enforcement authority was given to the Federal Trade Commission. This dual responsibility existed until 1972, at which time Congress enacted the Consumer Product Safety Act. This Act created the Consumer Product Safety Commission (CPSC). Standards writing and enforcement powers were transferred to CPSC effective May 14, 1973.

The Consumer Product Safety Commission has prescribed a two-step procedure for the development of flammability standards, as briefly outlined below:

1. Issue a notice of findings that a new flammability standard is needed, setting forth proposed standard. Afterwards, interested parties may then respond, for or against, the subject of "need" or the specifics of the proposed standard itself.

2. Publish the final standard, the date of compliance usually being twelve months from publication date unless an earlier or later date is deemed in the public interest. Judicial review can be filed for at any time within sixty days after promulgation by any party adversely affected.

While CPSC has the responsibility for flammable fabrics, the Commission must generally follow the provisions of the Flammable Fabrics Act in developing standards and in their administration and enforcement. This Act provides for an Advisory Committee with members representing industry and consumers. CPSC must consult with this committee during the aforementioned procedure, the intent being to ensure establishment of "reasonable, technologically practical, and appropriate" standards that will protect the public against "unreasonable risk."

On July 29, 1974, the CPSC met with the Advisory Committee to outline Commission plans for studying the possible extension of flammability standards to specified apparel categories. The Commission presented

a limited amount of burn data which were used to establish the following as high priority items for FR standards:

Priority	End Use
1	Women's Nightgowns
2	Women's Robes
3	Men's and Women's Pajamas
4	Women's and Children's Dresses
5	Men's and Boys' Shirts
6	Men's and Boys Trousers

Several states have passed legislation relating to flammable textile materials. The state laws are somewhat similar to the federal laws in regard to objectives, regulations, standards, and enforcement procedures. However, differences are evident. For example, the wider range of textile materials are covered and the effective dates are not the same. Of particular impact are situations where a state may impose wider coverage than that initiated by CPSC, as in the case of California. Here, state standards have national implications.

In addition, national research and trade organizations publish standards in an attempt to more realistically evaluate the real life situation.

Federal legislation is outlined in Appendix D-1 and D-2; state legislation in D-3 through D-5; and a host of test methods and their sponsors in Appendix D-6 through D-14.

The State of FR Technology

Fire retardant treatments are usually classified broadly as nondurable, semidurable and durable.

Innumerable nondurable water-soluble, inorganic compounds, as well as some organic ones, can be considered as potential flame retardants, because any nonflammable material will act as an inhibitor to the burning character of a fabric if added in sufficiently great quantities. However, to qualify as an effective fire retardant for textiles, the salt or mixture must be very efficient and it must not significantly impair other desirable properties, such as hand, color, strength, and permeability. Some additional problems with the soluble salts are: tendering of the fabric during treatment or upon prolonged storage (sulfamate and phosphate salts); crystallization on the fabric surface when subjected to varying humidities; necessity of high add-ons, 15-20%; and afterglowing, which in some instances may reignite the fabric into flame. Some metal oxides, in particular, actually accelerate the glowing tendency, acting as catalysts. Because these materials are water soluble, they are susceptible to leaching or migration due to various types of water leaching, high humidity, and perspiration.

Semidurable fire retardants are those that resist removal by one and up to about 15 launderings. Such retardants are adequate for many end-use products such as drapes, upholstery, and mattress ticking. If they are sufficiently resistant to sunlight or can be easily protected from actinic degradation, this type retardant is also useful for outdoor textile products such as beach umbrellas, tents, and cover fabrics.

Most of the effort to develop semidurable retardants has been for cotton and based on a combination of phosphorus and nitrogen compounds since it has been known for over 30 years that this combination of elements produces efficient fire retardants. For example, a mixture of dicyandiamide/formaldehyde and ammonium phosphate when applied to fabric, dried, and cured, polymerizes to form a resin. At the 140-150°C cure temperature, the phosphate decomposes to liberate phosphoric acid which causes excessive fabric tendering. However, drying and curing below 140°C causes polymerization in the fabric and avoids fabric tendering. The finishes resist mild washing, but not hot washing with soap. The process has been used commercially in a minor way for upholstery fabrics.

Durable fire retardants provide the desired degree of retardancy for the useful life of the textile product. This can mean durability for 50 or more laundry cycles and usually signifies durability to at least 15 cycles. Durability to laundering or other cleaning methods is just one of several criteria a fire retardant must meet to be satisfactory and acceptable for use in fabrics for specific textile products. Some of the more important criteria include strength retention, stiffness, and discoloration of the treated material. Other criteria that can sometimes disqualify a finish are ion exchange properties, odor, and sensitivity to acid or base. Until now, the successful and potentially acceptable fire retardants for cotton and rayon fabrics are of three general types: (a) metal oxides, (b) water-soluble monomers, which penetrate the fiber react and polymerize or copolymerize with an appropriate monomer and, in some systems simultaneously react with the cellulose, and (c) pre-formed polymers which are deposited on the surface of the fibers and subsequently are either further polymerized or fused to provide durability. Substitution reactions without polymer formation, such as phosphormethylation with chloromethyl phosphonic acid, have been carried out to impart flame retardancy but these have been unsuccessful for one or more reasons, such as ion exchange.

Fibers of many types are being blended in order to produce end-use products with specific properties. Most often a blend product contains a cellulosic fiber and a thermoplastic type fiber such as a polyester with cotton or rayon. Now with the urgent need for fire-resistant textiles, combinations of fibers are being made in an effort to develop fire resistance without the need for chemical finishing of fabrics. In addition, blends of various fibers in fabrics are being chemically treated to impart fire retardancy.

Blends of two inherently fire-resistant fibers is one obvious way of obtaining fire-resistant blend products. This route for obtaining better fire-resistant products has considerable merit. At present, the possibilities are limited mainly because of the limited availability of fire-retardant fibers.

Compounds which contribute fire retardancy generally contain elements from one of two groups of the periodic table: group 5 elements which contribute fire retardancy are nitrogen, phosphorus, arsenic, antimony, bismuth; group 7 elements are chlorine, bromine, and iodine. In addition to these which are useful in durable fire retardants, some compounds of boron are very useful in contributing nondurable retardancy. For most efficient fire retardancy- these elements are used in combination; for example, phosphorus is seldom used alone. It is generally used with either nitrogen or bromine. The halogens are generally used with an oxide of antimony or with some other metal oxide.

As a consequence fire retardant finishes incorporating these chemical elements are in commercial production.

A summary listing of fire retardant finishes and fibers appear in Appendix E.

Cotton batting is a blend of various low grades of cotton fibers. Generally, it is composed of about 60% first cut linters and 40% textile wastes. The ratio can vary depending upon economic situations and specific properties needed in the end-use products. Treatment of the raw stock of the cotton batting (as picker lap) appears to be the easiest and cheapest way to apply fire retardants in the production of fire resistant batting. Excess solution is removed by an appropriate technique and the picker lap is opened prior to drying.

A number of chemical systems are adequate for imparting fire resistance to cotton batting and picker lap. However, many inorganic retardants are not completely satisfactory. The inorganic borates and the ammonium phosphates tend to be lost from the treated fibers under high relative humidity conditions. They are also lost when the samples are soaked in water. Ammonium phosphates are also subject to decomposition at high temperatures and can degrade the fibers. Sodium and other metal borates when used alone generally produce considerable afterglow. Very little, if any, afterglow should be permitted in treated batting. Borated amido phosphates are effective retardants for cotton batting. Methylol derivatives of phosphoric acid-dicyandiamide reaction products are good retardants. Although some ammonium phosphates are not appropropriate, propyl ammonium phosphate appears suitable for batting. Urea phosphate complexes are among the more efficient fire retardants for batting.

Fire retardancy of the batting can be enhanced by use of a fire retardant containing phosphorus and a nitrogenous thermosetting resin. A secondary benefit from such a combination is the improved resilience achieved. The presence of a properly selected thermosetting resin also tends to make the fire retardant more stable and more difficult to remove from the cotton.

Progress Toward Objectives

Contributions to Scientific Knowledge

The fire research program in the Agricultural Research Service has increased during the time frame to reflect national needs in the area of human safety as judged by number of projects (Appendix F-1). This is evident from data compiled by the National Research Council, which shows the growing number of textile flammability references that appeared in the literature and profile of reports issued, at the beginning and end of the time frame (Appendix F-2 and F-3). It appears; however, that the data are incomplete from the industry sector since a much greater effort has been exhibited judged by the number of finishes and fibers in the commercial market.

SRRC/ publications in the flammability field have shown a steady increase as well as the requests for copies of reprints. At the same time technical journal coverage increased as the program increased in scope (Appendix F-4 and F-5). ARS has published a total of 146 technical publications on textile flame retardancy during the time frame.

A total of 100 significant accomplishments were achieved during the time frame ranging from basic work on mechanism of the flameing process and synthesis of new compounds to the development of commercial processes (Appendix F-6 through F-12). Based on some of these accomplishments and within the time frame, a total of 77 patents have been applied for. As of the present 54 have been issued and 23 are pending. These are enumerated in detail by title in Appendix F-13 through F-25.

Commercialized Products

It has been known for many years that certain phosphorus-containing compounds can be applied to cellulosic fabrics to make them resistant to burning. All such finishes based on phosphorus-containing compounds have one common property: they make the fabric resistant to smoldering, and even if insufficient finish is applied to prevent the fabric from burning, the residue will not be ash but a black char, a skeleton of the fabric, which is extremely resistant to prolonged fierce heating. Many compounds not containing phosphorus can be used to reduce the flammability of cellulose but very few are effective in preventing smoldering or afterglow. These few are for other reasons not commonly

used or not as efficient as the phosphorus compounds, and it can be said that as a flame and glow proofer phosphorus holds a unique position.

Finishes based on soluble phosphates are not fast to washing, and it is only natural, therefore, that efforts should have been made to obtain more permanent effects by fixing the phosphorus on or in the fabric. Later research proved that a certain phosphorus nitrogen balance must be maintained.

The Southern Regional Research Center pioneered this research and developed two commercial finishes that are presently used: the Thpc-amide and the THPOH-ammonia finish. The basic compound Thpc and the basic finishes Thpc-amide and THPOH-ammonia have been developed by the Southern Regional Research Center and manufactured by several chemical concerns. Another finish is also in commercial use to a limited extent and is known as Pyrovatex CP. Pyrovatex (a dialkyl-phosphonopropionamide) was introduced in the United States by the Ciba Chemical and Dye Company. A commercial finish called Proban is based on Thpc, urea, and ammonia. This finish is manufactured in England and used in Europe and the Mid-East exclusively.

Flow charts are shown in Appendix F-26 through F-28 of the typical THPOH-ammonia and Thpc-amide finish system.

Occasionally private firms recognize such contributions by the Department in their advertisements to users and the general public. These also are shown (Appendix F-29 through F-31).

A number of techniques have been devised at the Southern Regional Research Center to treat cotton batting with boric acid, among which are (a) dusting powdered boric acid onto the fibers after garnetting, (b) an adptation of an immersion and dewatering system applied to the raw stock before garnetting. Both techniques are used commercially.

A product incorporating resiliency, strength and fire retardancy has also been developed by Southern Regional Research Center scientists and is commercially sold as "Cotton Flote." In this process, flame retardants (usually inexpensive urea phosphates) are added to a resin-latex bath which is generally applied at the web stage of formation.

Technical Assistance to Users

Technical publications, in some form or fashion, are used as an index of productivity and accomplishment because publication is considered to be the end product of research. However, when translated to a commercial product, based on such research, additional informational or educational vehicles are required. These are: explanatory and informational letters, telephone consultations, formal public meetings, pilot-plant trials, commercial mill runs, and laboratory tours (technical and general public).

Data have been collected during the last 7 year period to illustrate contacts that have been made via letter and telephone. Over 1300 such individual contacts were made including 40 states and 17 foreign countries explaining published research on fire retardant cotton products. Almost 120 subjects related to fire retardance were discussed, and 21 specific finishing systems that were developed at the laboratory (Appendix F-32 through F-39).

In addition to attendance and forum participation at national meetings, the Southern Regional Research Center organizes and sponsors two annual meetings where our total research effort on cotton textiles and cotton batting (related to cottonseed) are described. Attendance includes representatives from industry, trade groups, other government agencies and universities (Appendix F-40 through F-42).

Many potential users have asked that their fabrics be treated on a semicommercial scale. Yardages from 100 to 500 have been test run for this purpose and evaluated by the textile finishers. At the same time SRRC personnel gained experience and knowledge in treating different fabric systems and the research problems posed by these systems. Commercial firms have also sent their personnel to SRRC to gain experience in handling FR finishes during these pilot plant runs. Approximately 180 such runs have been made. In addition, scientists from SRRC have participated in actual commercial textile mill trials which totaled 96 during this period (Appendix F-43 through F-46).

Tours of the Southern Regional Research Center facility are conducted to provide technical assistance and for general educational purposes. These tours include the general public as well as technical people from regional or national technical conferences that are held in New Orleans. During these tours, research on FR finishes is discussed and demonstrated. Over 700 tours were conducted during this period which included 10,000 people (Appendix F-47).

Evaluation of Program Effectiveness

The evaluation of effectiveness is based on a specific objective--development of selective textile products that are flame retardant. Further, the objective was established through the legislative process which expresses society's concern for health, safety, and the general welfare. This situation leads to a general cost and benefit structure that is based on the proposition that "if a current action (fire retarding textiles) is taken the societal effects of future events (textile fire and injuries) will be altered or will not occur."

A limited national statistical base is available on fires, fire injuries and death, medical costs of burn injuries, and specifically on fires and their related injuries that did not occur due to flame retardant textile products. Despite the limited statistical base analytical data

was developed from numerous sources. Administrative documents were used to develop program and implementation costs. Benefits were developed from aggregative statistical series published by such agencies as the U.S. Department of Commerce, CPSC, NCC, DHEW and CI. Personal communications with various hospital Burn Institutes and with individuals were initiated to obtain data on 13 cases in which fire retardant pajamas, nightwear, and bedding were thought to be instrumental in reducing the effects of textile fire injuries and/or death.

The research program has developed new knowledge contributing to the reduction of hazards to the health and safety of people. Thirteen documented cases of sleepwear and mattress fires prevented in 1973 as a consequences of this program are summarized in Table III. This can be regarded as a minimum annual impact since it represents only those cases which were reported in which it was documentable that fire retardant textile prevented serious injuries. This is impressive enough, but the potential annual reduction in deaths and hospital stays due to complete suppression of injuries from the burning of sleepwear (0-6X) and mattresses as shown in the lower part of Table III-A is even more so. Table III-A indicates a total of 229 deaths prevented, 1486 lengthy hospital stays avoided, and 1107 visits for treatment eliminated. These results have been made possible at a total expenditure of $8.4 million in cotton flame retardancy research in ARS.

Perhaps at this point a comment is appropriate on the problem of quantifying the unquantifiable or, cost-benefit analysis of a human life. This subject is described effectively in a Business Week article of June 30, 1975 (p. 114) which is quoted in part:

> "Economists have been breaking new ground in applying an old but still controversial technique called cost-benefit analysis to evaluate government regulation and government programs. And they have come up with some startling conclusions that will generate heated debate not only in halls of academia but also in the power centers in Washington. Studies on the existing regulation of the drug and auto industries, for example, find that some heretofore sacrosanct legislation is, on balance, detrimental or of little benefit to the public interest. Other studies, however, show that the nation may be spending far too little on programs that save human lives in other areas.....
>
> "The idea of cost-benefit analysis is to bring to government programs the same kind of quantitative analysis that

goes into business decisions. To decide whether a prospective investment is sound, the business executive adds up the costs and compares them with the expected returns. If the benefits exceed the costs, then the investment is worthwhile.

"But the evaluation of government programs raises special problems. Cost estimates are usually no more difficult than in the private sector. There are, however, few signals from the marketplace to help economists estimate benefits, especially for such social benefits as the saving of a human life. Government services are almost never sold for a price, so their value can be measured only indirectly. This has not, however, stopped economists from measuring the benefits as well as the costs of virtually every government program in sight. Three recent studies using this technique reach conclusions, which are both arresting and already in dispute.

"Cost-benefit analysis is well over 100 years old, but it is still in its infancy. There are scores of theoretical and measurement barriers to hurdle. And, perhaps wisely, most decisions will still be made on political rather than economic grounds. Nevertheless, it is clear that congressmen and bureaucrats alike will be relying more and more on this technique to prove that their rules, regulations, and pet programs are worth what the taxpayer is shelling out for them."

The data in this study reflect minimum benefits that could be expected and the costs are those relating to research and development of fire and smolder retardant cotton products. Benefits are those that could be substantiated for 13 fire incidences, cotton market retention, the net value added for fire retardant chemical production and the net value added relating to the installation of batting machinery systems. Benefits are also projected to a 1973 base to reflect the potential annual benefits obtainable if all pajamas, nightgowns, and mattress fires and related injuries could be eliminated.

The costs and benefits are summarized in the following tables. The costs are for the 1964-73 period and benefits are for 1973. The accumulated cost was $8.4 million and annual benefit was $17.8 million. The potential annual benefits if all fire related injuries were eliminated would be $51.8 million (sleepwear 0-6X and mattresses only). This value corresponds to an independent study by J. Schmitt and R. Dardis (The University of Maryland at College Park) where total benefits to health and safety are calculated at $42 to $56 million (discounted at 4%) or $41 to $52 million (discounted at 6%). It

should be emphasized that the benefits reported in the SRRC study are not based on a total potential savings in health and safety but only on the 13 known cases that have been documented and assumes that these lives have been saved due to the documented use of flame retardant sleepwear and mattresses.

SUMMARY OF COST AND BENEFITS FROM THE FIRE AND SMOLDER RETARDANT COTTON PRODUCTS PROGRAM, SRRC, 1964-1973

COSTS, 1964-1973 (1973 basis)

RESEARCH RESOURCES, SRRC[1/]	$6,806,669	
TECHNOLOGY DISSEMINATION, SRRC[2/]	1,554,117	
TOTAL		$8,360,786

BENEFITS, 1973

SAVINGS ON HEALTH AND SAFETY[3/]	2,122,978	
NET VALUE ADDED[4/]		
FIRE RETARDANT CHEMICAL PRODUCTION	11,686,779	
BATTING MACHINERY SYSTEM	1,224,739	
COTTON MARKET RETENTION[5/]		
TEXTILE	920,960	
BEDDING	1,877,400	
TOTAL ANNUAL BENEFITS		$17,832,856

FOR METHOD OF COMPUTATION SEE TABLES THIS SECTION AND APPENDIX TABLES.

1/ Table I
2/ Table II
3/ Table III
4/ Table IV
5/ Table V

TABLE I

RESEARCH RESOURCES ALLOCATED TO THE FLAME RETARDANT AREAS
SRRC, 1964-1973

	FIRE RETARDANT PROGRAM AREA			SRRC LOCATION LEVEL BUDGET	FIRE RETARDANT PROGRAM AREA
	SY	DOLLARS	1973 VALUES 1/	DOLLARS	PERCENT
1964	2.4	83,000	163,269	5,858,435	0.01
1965	2.0	68,300	125,563	6,207,861	0.01
1966	4.0	136,000	253,662	6,884,252	1.98
1967	7.0	224,700	360,801	7,668,906	2.93
1968	10.9	458,000	687,321	8,076,586	5.67
1969	10.8	411,000	576,428	8,005,889	5.13
1970	14.1	594,000	778,556	8,314,942	7.14
1971	21.9	981,000	1,201,725	8,685,645	11.29
1972	29.8	1,342,000	1,556,456	8,764,094	15.31
1973	30.5	1,030,736	1,102,888	7,555,700	13.64
TOTAL	133.4	5,328,736	6,806,669	76,022,310	-----

1/ VALUE IN 1973 IF INTEREST COMPOUNDED ANNUALLY AT 7%.

TABLE II

TECHNOLOGY DISSEMINATION

	VALUE
Technical presentation, cotton utilization conferences[1/]	162,211.58
Technical presentations, cotton batting workshop[2/]	19,195.26
Technical presentations, CCSAES[3/]	3,441.50
Technical presentation, Oilseed Processing Clinics[4/]	12,203.73
Technical presentations, non-SRRC conferences[5/]	642,067.38
Batting Institute Meeting and Directors of Research Committee Meeting, SRRC, 1970, 1971, 1973[6/]	60,091.74
In-plant technical consultations[7/]	160,167.85
Visitor consultations at SRRC[8/]	87,891.34
Technical consultations, letters and telephone[9/]	10,546.50
Laboratory visitors[10/]	3,679.26
TOTAL	1,161,496.14 (1,554,117.55)[11/]

1/ Appendix G-1, G-2
2/ Appendix G-3
3/ Appendix G-5
4/ Appendix G-4, G-6
5/ Appendix G-7, G-8
6/ Appendix G-9
7/ Appendix G-10, G-11, G-12
8/ Appendix G-13, G-14, G-15
9/ Appendix G-16, G-17, G-18, G-19, G-20
10/ Appendix G-21, G-22
11/ Compounded at 7% using the formula $C=c(1+r)^t$ and appears in Summary Table of Costs and Benefits.

TABLE III

SUMMARY OF MEDICAL AND INCOME SAVINGS DUE TO FIRE RETARDANT SLEEPWEAR (0-6X) AND MATTRESSES - 1973

		SAVINGS				
	CASES[1]	MEDICAL TREATMENT DOLLARS[2]	HOSPITALIZATION[3]	INCOME[4]	TOTAL	TOTAL PRESENT VALUE[5]
SLEEPWEAR (0-6X	12	300	123,318	5,746,476	5,870,094	1,956,502
MATTRESS	1	25	10,277	239,437	249,739	166,476
TOTAL	13	325	133,595	5,985,913	6,119,833	2,122,978

1/ IT WAS ASSUMED THAT EACH CASE WOULD HAVE RESULTED IN A 46.5 DAY HOSPITAL STAY AND DEATH IF FIRE RESISTANT NIGHTWEAR AND MATTRESSES HAD NOT BEEN AVAILABLE. SEE THE DISCUSSION OF NEGATIVE DATA, APPENDIX G-25 TO G-27.

2/ COST OF INITIAL HOSPITAL ADMISSION OR TREATMENT $25 OR 13 x $25 = $325.

3/ COST OF HOSPITALIZATION $211 x 46.5 DAYS x 13 = $133,595.

4/ INCOME SAVINGS FOR THOSE BELOW 18 YEARS OLD 12 x $478,873 AND FOR THOSE ABOVE 18 YEARS OLD 1 x $239,437.

5/ PRESENT VALUE COMPUTED BY THE FORMULA $PV = \frac{R}{n} \times \frac{1-(1+r)^{-n}}{r}$ WHERE R = FUTURE INCOME, n = NUMBER OF YEARS (40 FOR 0-6X AGE AND 20 FOR ALL OTHER AGES) AND r = DISCOUNT RATE OF 7%.

TABLE III-A

ESTIMATED PRIMARY MEDICAL COST AND FUTURE INCOME LOSS DUE TO FIRST TO IGNITE NIGHTGOWN, PAJAMA (0-6X) AND MATTRESS FABRIC FIRE INCIDENCES

	TREATED AND RELEASED		HOSPITAL		DEATHS		TOTAL COST DOLLARS
	NUMBER CASES	COST DOLLARS	NUMBER CASES	COST DOLLARS	NUMBER CASES	COST DOLLARS	
COST AND INCOME LOSSES ON REPORTED 1966-1973 CASES							
NIGHTGOWNS & PAJAMAS (0-6X)	19	475	54	554,931	7	1,117,258	1,672,664
MATTRESS	53	1325	53	544,655	9	1,436,478	1,982,458
TOTAL	72	1800	107	1,099,586	16	2,553,736	3,655,122
COST AND INCOME LOSS PROJECTED TO A 1973 NATIONAL BASE							
NIGHTGOWNS & PAJAMAS (0-6X)	198	4950	577	5,929,651	76	12,130,236	18,064,837
MATTRESS	909	22725	909	9,341,449	153	24,420,132	33,784,306
TOTAL	1107	27675	1486	15,271,100	229	36,550,368	51,849,143

NOTE: Projected 1973 injuries were primarily computed from data from CPSC Annual Report (U.S. Consumer Product Safety Commission, First Annual Report, Fiscal Year 1973, Nov. 1973, Washington, D.C.). The 0-6X nightgown and pajama cases were based on a ratio of the type:

$$\frac{a}{b} = \frac{c}{d}$$

$$\frac{28,000}{X} = \frac{4508}{140}$$

(continued)

(a) Unpublished 1973 national injuries due to textiles.
(b) 1973 projected injuries 0-6X nightwear.
(c) Fabric fire incidence cases for the 1966-73 period (limited sample).
(d) 0-6X nightwear and pajama fire incidence for the 1966-73 period (same limited sample).

Mattress cases were based on a similar ratio:

$$\frac{a}{b} = \frac{c}{d}$$

$$\frac{31,000}{X} = \frac{2585}{240}$$

(a) Unpublished 1973 national cases in which mattresses were the first item ignited.
(b) 1973 projected mattress injuries.
(c) Mattress fire incidence cases for the 1966-73 period (limited sample).
(d) Cases in which mattresses were the first to ignite for the 1966-73 period (same limited sample).

These ratios resulted in a 1973 national projection of 870 cases for 0-6X nightwear and 2878 cases for mattresses. The disposition of these injury cases (1973 National Base) and those for the 1966-73 period were computed from the frequency distribution shown in Appendix Tables G-23 and G-24, wherein it is noted that the dispostion of some cases is unknown or untreated.

TABLE IV

NET VALUE ADDED ASSOCIATED WITH PRODUCTION OF FIRE RETARDANT CHEMICALS AND BATTING MACHINERY SYSTEMS

	DOLLARS
VALUE ADDED, FIRE RETARDANT CHEMICALS[1/]	11,686,778.53
VALUE ADDED, BATTING MACHINERY[2/]	1,224,739.32
TOTAL VALUE ADDED	12,911,517.85

1/ TOTAL REQUIREMENT COEFFICIENTS PUBLISHED IN THE INPUT-OUTPUT STRUCTURE OF THE U.S. ECONOMY: 1967, VOL. 3, U.S. DEPARTMENT OF COMMERCE X $8,877,356 (COST OF ADDITIONAL FR CHEMICALS, APPENDIX TABLE G-28) = $20,575,314.32 (ADDITION TO FINAL DEMAND ASSOCIATED WITH OUTPUT OF FR CHEMICALS) X 56.8% (PERCENT VALUE ADDED IS OF TOTAL CHEMICAL INDUSTRY SHIPMENTS) = $11,686,778.53 VALUE ADDED ASSOCIATED WITH ADDITION TO FINAL DEMAND).

2/ TOTAL REQUIREMENT COEFFICIENTS X $94,500 (VALUE OF 35 APPLICATORS, (APPENDIX TABLE G-29) = $2,141,152.65 (ADDITION TO FINAL DEMAND ASSOCIATED WITH INSTALLATION OF MACHINERY SYSTEM) X $1,224,739.32 (VALUE ADDED).

TABLE V

COTTON MARKET RETENTION ATTRIBUTABLE TO THE AVAILABILITY OF FIRE RETARDANT TREATMENT SYSTEMS

	POUNDS COTTON[1/] AND LINTERS 1000 LBS.	PRICE/UNIT[2/] CENTS	DOLLAR VALUE
SLEEPWEAR	1,439	64.00	920,960
BEDDING	21,000	8.94	1,877,400
TOTAL	22,439	----	2,798,360

1/ POUNDS OF COTTON LINT AND LINTERS USED IN 1973.

2/ PRICE FOR COTTON LINT LANDED GROUP B MILL POINTS AND U.S. AVERAGE PRICE FOR GRADE 2 STAPLE 2 LINTERS ALL MARKETS, 1973.

NOTE: ASSUMES A 100 PERCENT MARKET LOSS IF COTTON MATERIALS DO NOT MEET FEDERAL FLAME RETARDANCE STANDARDS.

SEE APPENDIX TABLE G-30 - G-33 FOR PRICE AND VOLUME TRENDS.

An Evaluation of Research on Fire and Smolder Retardant Cotton Products

APPENDIX

October, 1975
Southern Regional Research Center
Agricultural Research Service, USDA
New Orleans, Louisiana

PROGRAM OBJECTIVES

Appendix-A

Fire Retardance Research Objectives

Southern Regional Research Center, 1964-1973

YEAR	OBJECTIVE
1964-65	To develop durable inexpensive flame retardants for cotton that do not cause loss in strength and other desirable properties inherent in the cotton fiber.
1966	To impart to cotton, properties such as flame, wrinkle, strain, and/or abrasion resistance through the use of compounds which are cellulose reactive or which can form polymers, particularly organic compounds containing phosphorus, nitrogen, or fluorine.
	To treat fabrics with flame retardant polymers to produce fabrics having a high degree of flame resistance and abrasion resistance, and exhibiting durable press properties.
1967	The task of developing effective flame-retardant finishes for cotton is different because of the many requirements the finish must meet. To be satisfactory for most uses, a flame retardant must: - be reasonable in cost; - be effective at low addition of finishing agent to avoid excessive increases in weight; - be easy to apply, preferable with existing finishing equipment from a water solution or organic solvents; - render the fabric resistant to afterflow; - not stiffen or discolor the fabric; - cause little or no loss in strength and abrasion resistance; - be physiologically inactive; - leave the fabric air-permeable; - resist laundering and drycleaning; and - not liberate toxic gases when exposed to flame.

1968 To develop processes or techniques for producing flame retardant conventional cotton batting and dimensionally stable, highly resilient resin treated cotton batting which will:

(1) When tested by AATCC method 34 (1966) have:
   a. Afterflame time of less than 1 second.
   b. Afterglow time of less than 2 seconds.
   c. Char length of less than 6 inches.

(2) Have no undesirable odor.

(3) Have no physiological effects.

(4) Be stable and resist:
   a. Removal by high relative humdity.
   b. Removal by elevated temperature.
   c. Removal by leaching with water.
   d. Removal or inactivation by ageing.

(5) Utilize an aqueous media for the application of the chemicals.

(6) Not exceed 5 cents per pound to treat the products.

To develop cotton products with:

A. Flame resistance and other desirable properties, such as glow resistance, rot resistance, durable press, nonyellowing during treatment and/or after bleaching, improved abrasion, and high strength retention.

B. Flame resistance such that they will pass the standard vertical flame test with a char length of not more than 3-1/2 inches for fabrics over 23.0 oz/sq yd for any one specimen, and not more than 6-1/2 inches for fabrics weighing over 2.0 to 10.0 oz/sq yd for any one specimen.

C. Flame resistance that will reduce the time of flame spread of a fabric when tested at a 45 degree angle, and is especially designed for textiles which ignite easily, such as napped, pile, tufted, flocked or similar surface.

D. Flame resistance that will withstand laundering and/or drycleaning for the life of the fabric for durable flame-resistant materials, or that will withstand a lesser number of launderings and/or drycleanings for semidurable finished materials, such as rugs, drapes, napped sweat shirts, etc.

E. Flame resistance with air permeability and a soft hand, especially when applied to lightweight material.

F. Flame resistance that is physiologically inactive.

G. Flame resistance at a minimum increase in cost of the finished product. The cost should not be more than that of a comparable synthetic material.

H. Flame resistance that will not produce any more toxic or undesirable fumes at high temperatures than polyamide fibers.

I. Flame resistance which when subjected to high temperatures will produce a high char to tar ratio.

J. Flame resistance and other desirable properties economically prepared on existing mill equipment.

1969 To develop lightweight cotton fabric products with adequate flame resistance and other desirable properties required by the end use, such as glow resistance, durable press, improved abrasion resistance, and high-strength retention:

A. That will withstand laundering and/or drycleaning for the life of the fabric.

B. That are permeable to air and have a soft hand.

C. That are physiologically inactive.

D. That will not produce any toxic or undesirable fumes at high temperatures.

E. That will not cost over 12 cents a yard for medium weight fabrics.

F. That does not turn yellow when exposed to hypochlorite bleaches.

1970 Same as 1969.

1971

A. Develop lightweight cotton fabric products with adequate resistance and other desirable properties required by the end use, such as glow resistance, durable press, improved abrasion resistance, and high-strength retention:

(1) That will withstand laundering, line drying, and/or drycleaning for the life of the fabric.

(2) That are permeable to air and have a soft hand.

(3) That are physiologically inactive.

(4) That will not produce any toxic or undesirable fumes at high temperatures.

(5) That will not cost over 12 cents a yard for medium weight fabrics.

(6) That does not turn yellow when exposed to hypochlorite bleaches.

B. Develop processes or techniques for producing flame-retardant conventional cotton batting and dimensionally stable, highly resilient resin-treated cotton batting which will:

(1) When tested by AATCC method 34 (1966) have:
a. Afterflame time of less than 1 second.
b. Afterglow time of less than 2 seconds.
c. Char length of less than 6 inches.

(2) Have no undesirable odor.

(3) Have no physiological effects.

(4) Be stable and resist:
a. Removal by high relative humidity.
b. Removal by elevated temperature.
c. Removal by leaching with water.
d. Removal or inactivation by ageing.

(5) Utilize an aqueous media for the application of the chemicals.

(6) Not exceed 5 cents per pound to treat the products.

1972 Same as 1971, except A (6) reads, That does not yellow or lose flame-resistance when exposed to hypochlorite bleaches.

1973 (a) Develop chemical systems for imparting durable fire resistance to fabrics which have minimum adverse effect upon physical and aesthetic properties of the finished fabric, and which will meet expected and present standards, (b) develop methods, techniques, and equipment for applying flame retardance finishes which can be adapted to textile mill use, (c) determine the parameters which affect the nature, durability, comfort, and aesthetic characteristics of flame retardance finishes, (d) devise test methods for evaluating rapidly the flame retardancy of textile items, which tests correlate behavior of the items in actual end-use situations, (e) develop cotton products for use in mattresses, upholstery, furniture, and automotive seating which comply with Federal Standards for flammability performance, (f) elucidate the mechanisms of flame retardance as a basis for development of more effective treatments, and (g) develop fire retardants which reduce or eliminate the production of toxic vapors during pyrolysis.

IMPROVEMENT OF PROPERTIES OF COTTON
FOR FANCY JERSEY KNITS

PROPERTY	Thpc-CYANAMIDE LOW ADD-ON	THPOH-NH_3 LOW ADD-ON	PERCENT CHANGE (IMPROVEMENT)
BURSTING STRENGTH, LBS./IN.^{2}	90	103	14
STIFFNESS, WARP, IN. LBS. X 10^{-4}	5	4	20

IMPROVEMENT OF PROPERTIES OF NAPPED
COTTON SOFT FILLED SHEETING

PROPERTY	NO TREATMENT 65% RELATIVE HUMIDITY	THPOH-AMIDE TREATED 65% RELATIVE HUMIDITY	PERCENT CHANGE (IMPROVEMENT)
CHAR LENGTH, IN.	10.0	1.6	84
OXYGEN INDEX	17.8	32.5	83

IMPROVEMENTS OF PROPERTIES OF COTTON FOR FLANNELETTE

PROPERTY	Thpc-AMIDE 1963	THPOH-AMIDE 1973	PERCENT CHANGE (PERCENT)
CHAR LENGTH, IN.	10.0	1.5	85
BREAKING STRENGTH, LB. WARP	111	143	29
TEARING STRENGTH, GRAMS WARP	1980	2367	20
WRINKLE RECOVERY, DEG. (W+F)	228	283	24
STIFFNESS, (W+F) IN.-LB. X 10^{-4}	45	17.5	61

IMPROVEMENTS OF PROPERTIES OF COTTON FLOTE FOR MATTRESSES
1967-1973

PROPERTY	1967 UNTREATED COTTON FLOTE	1973 TREATED COTTON FLOTE	PERCENT CHANGE (IMPROVEMENT)
RESILIENCE	91.8	97.1	5.8
AFTERFLAME, SEC.	1.0	0.0	100.0
AFTERGLOW, SEC. VERTICAL FLAME	11.0	1.0	90.9
PERMANENCE, AFTERGLOW, SEC., 7 MO. AT AMBIENT	12.0	0.0	100.0
MEET STANDARD FF4-72	NO	YES	-----

IMPROVEMENT OF PROPERTIES OF COTTON FLOTE FOR AUTOMOTIVE USE
1967-1973

PROPERTIES	1967 UNTREATED COTTON FLOTE	1973 TREATED FLOTE	PERCENT CHANGE (IMPROVEMENT)
RESILIENCE	91.8	93.6	2.9
AFTERGLOW, SEC. VERTICAL FLAME	11.0	0.0	100.0
AFTERFLAME, SEC. VERTICAL FLAME	1.0	0.0	100.0
PERMANENCE, AFTER 7 MO. AMBIENT	12.0	0.0	100.0
BURN RATE, IN./MIN.	3.5	1.0	71.4
MEETS MUSS 302	NO	YES	----

STATISTICS ON TEXTILE FIRES

Appendix-B

UNITED STATES FIRE DEATHS AND FIRES

	NUMBER FIRE DEATHS	FIRE DEATH PER MILLION POPULATION	FIRES PER 1,000 POPULATION
1960	11,350	63.0	11.8
1961			12.0
1962			12.2
1963			13.1
1964			12.4
1965	12,000	61.9	12.1
1966			12.2
1967			12.1
1968	12,100	60.7	11.8
1969	12,100	60.1	12.0
1970	12,200	59.9	12.5
1971	11,850	57.2	
1972	11,900	57.1	
1973	11,700	55.6	

SOURCE: Fire Journal. Various issues, National Fire Protection Association and Flammability News Bulletin, Vol. 3, No. 5, Mar.-Apr., 1975

ACCIDENT DEATHS CAUSED BY FIRE AND EXPLOSION OF COMBUSTIBLE MATERIALS, BY AGE

AGE	1964 NUMBER	1964 PERCENT[1/]	1973 NUMBER	1973 PERCENT[1/]	PERCENT CHANGE[1/] 1964 to 1973
TOTAL	7379	100.0	6503	100.0	-11.9
0-4	1274	17.3	846	13.0	-33.6
5-9	519	7.0	328	5.0	-36.8
10-14	207	2.8	198	3.0	- 4.3
15-19	122	1.7	207	3.2	69.7
20-24	210	2.8	307	4.7	46.2
25-34	457	6.2	491	7.6	7.4
35-44	752	10.2	532	8.2	-29.3
45-54	918	12.4	763	11.7	-16.9
55-64	868	11.8	959	14.7	10.5
65-74	906	12.3	856	13.2	- 5.5
75 & over	1146	15.5	1016	15.7	-11.3

1/ Computed; numbers rounded.

SOURCE: Unpublished data from DHEW, Plate 2, pp. 360-362 and Plate 1, pp. 360-362. Data obtained by personal communication with Robert J. Armstrong.

FIRE LOSSES IN THE UNITED STATES
1964-1973

	Million Dollars
1964	1,367.1
1965	1,455,6
1966	N.A.
1967	1,706.7
1968	1,829.9
1969	1,952.0
1970	2,264.0
1971	2,316.0
1972	2,304.0
1973	3,020.0

SOURCE: National Insurance Acturial and Statistical Association.

ESTIMATED UNITED STATES BUILDING FIRE LOSSES

	NUMBER OF FIRES 1,000	LOSSES MIL. DOLLARS
1964		
1965		
1966		
1967	960.9	1,623.0
1968	974.4	1,786.9
1969	973.0	1,933.8
1970	992.0	2,209.2
1971	996.6	2,266.0
1972	1,050.2	2,416.3
1973		

SOURCE: Fire Journal. Various issues. National Fire Protection Association.

ACCIDENT CIRCUMSTANCES AND SEVERITY OF BURNS BY CLOTHING IGNITION AND NO CLOTHING IGNITION

Accident Circumstances and Severity of Burn	Clothing Ignition	No Clothing Ignition
Throwing Fuel on Fire		
Number of cases	270	84
Days burn to discharge	68.6	54.6
Percent total burn	31.4	20.9
Percent full-thickness burn	14.0	0.8
Percent mortality	14.4	2.4
Brushing Against Stove		
Number of cases	328	11
Days burn to discharge	54.8	24.3
Percent total burn	23.9	4.9
Percent full-thickness burn	16.0	1.4
Percent mortality	15.8	0.0
Brushing Against Open Fire		
Number of cases	240	28
Days burn to discharge	56.7	35.7
Percent total burn	22.4	9.0
Percent full-thickness burn	15.4	4.1
Percent mortality	18.9	1.1
Brushing Against Heater		
Number of cases	245	12
Days burn to discharge	54.4	33.0
Percent total burn	28.6	4.0
Percent full-thickness burn	18.1	1.0
Percent mortality	18.3	0.0
Playing with Matches		
Number of cases	250	2
Days burn to discharge	56.6	n.a.
Percent total burn	22.0	6.0
Percent full-thickness burn	15.7	1.0
Percent mortality	10.4	0.0
Imprecise Data		
Number of cases	216	27
Days burn to discharge	41.8	24.1
Percent total burn	31.9	11.3
Percent full-thickness burn	20.0	1.8
Percent mortality	30.6	11.1

Accident Circumstances and Severity of Burn	Clothing Ignition	No Clothing Ignition
House Fire		
Number of cases	180	43
Days burn to discharge	50.5	34.1
Percent total burn	42.7	21.0
Percent full-thickness burn	26.2	5.4
Percent mortality	42.8	18.6
Land Vehicle Crash		
Number of cases	194	13
Days burn to discharge	61.9	40.3
Percent total burn	43.0	14.3
Percent full-thickness burn	27.3	3.0
Percent mortality	36.1	0.0
Smoking in Bed		
Number of cases	186	7
Days burn to discharge	84.0	23.4
Percent total burn	24.8	3.0
Percent full-thickness burn	17.3	3.0
Percent mortality	35.0	14.3
Combustible Liquid Container Explosion		
Number of cases	138	39
Days burn to discharge	56.1	33.5
Percent total burn	39.7	13.0
Percent full-thickness burn	16.9	0.7
Percent mortality	18.2	0.0
Heater and Stove Explosion		
Number of cases	128	44
Days burn to discharge	52.6	35.7
Percent total burn	43.8	27.6
Percent full-thickness burn	22.4	3.7
Percent mortality	38.3	9.1
Aircraft Crashes		
Number of cases	156	15
Days burn to discharge	88.3	60.9
Percent total burn	39.2	16.5
Percent full-thickness burn	19.4	5.4
Percent mortality	23.1	6.7

Accident Circumstances and Severity of Burn	Clothing Ignition	No Clothing Ignition
Working Around Engine and Combustible Fuel		
Number of cases	134	23
Days burn to discharge	44.8	21.0
Percent total burn	29.9	11.4
Percent full-thickness burn	14.8	1.5
Percent mortality	15.6	0.0
Smoking cigarette or Lighting Match Around Explosive Substances		
Number of cases	123	29
Days burn to discharge	46.6	22.9
Percent total burn	40.8	20.3
Percent full-thickness burn	17.2	0.8
Percent mortality	25.2	13.9
Handling Explosives		
Number of cases	103	43
Days burn to discharge	81.2	52.3
Percent total burn	34.4	20.8
Percent full-thickness burn	12.9	0.5
Percent mortality	12.6	2.0
Explosion at Place of Work		
Number of cases	111	17
Days burn to discharge	35.4	33.7
Percent total burn	50.8	24.9
Percent full-thickness burn	25.9	2.8
Percent mortality	46.0	11.7
Electrical Ignition		
Number of cases	103	13
Days burn to discharge	53.6	19.7
Percent total burn	42.3	16.6
Percent full-thickness burn	22.4	7.2
Percent mortality	28.2	15.4
Explosion While Igniting Stove or Heater		
Number of cases	80	35
Days burn to discharge	34.6	26.1
Percent total burn	34.2	11.4
Percent full-thickness burn	17.1	2.4
Percent mortality	33.7	2.9
Dropping Cigarette or Match on Self		
Number of cases	97	6
Days burn to discharge	46.2	30.0
Percent total burn	23.8	7.7
Percent full-thickness burn	17.6	1.5
Percent mortality	35.0	0.0

Accident Circumstances and Severity of Burn	Clothing Ignition	No Clothing Ignition
Acetylene Torch Total		
Number of cases	89	12
Days burn to discharge	47.3	23.9
Percent total burn	36.6	21.6
Percent full-thickness burn	17.9	1.7
Percent mortality	20.2	16.7
Suicide or Assault Attempt		
Number of cases	89	9
Days burn to discharge	48.4	25.0
Percent total burn	34.8	24.2
Percent full-thickness burn	22.5	4.8
Percent mortality	31.5	22.2
Extinguishing Fire and Rescue		
Number of cases	64	25
Days burn to discharge	48.0	32.7
Percent total burn	32.8	9.9
Percent full-thickness burn	16.7	0.3
Percent mortality	18.8	4.0
Explosion while Cleaning with Gasoline		
Number of cases	67	15
Days burn to discharge	51.1	38.3
Percent total burn	42.1	20.9
Percent full-thickness burn	19.2	1.9
Percent mortality	24.5	0.0
Approaching Flame with Fuel on Self		
Number of cases	65	5
Days burn to discharge	70.0	19.0
Percent total burn	23.9	6.2
Percent full-thickness burn	12.8	0.7
Percent mortality	7.4	0.0
Lantern Ignition Total		
Number of cases	37	5
Days burn to discharge	52.9	31.3
Percent total burn	32.7	6.0
Percent full-thickness burn	16.7	0.2
Percent mortality	24.3	0.0

Accident Circumstances and Severity of Burn	Clothing Ignition	No Clothing Ignition
Explosion while Handling Chemicals		
Number of cases	28	8
Days burn to discharge	34.0	29.0
Percent total burn	39.5	13.6
Percent full-thickness burn	22.7	0.1
Percent mortality	32.1	0.0
Miscellaneous, Total		
Number of cases	22	10
Days burn to discharge	45.4	22.5
Percent total burn	30.8	15.2
Percent full-thickness burn	19.3	6.5
Percent mortality	18.2	0.0
Marine Explosion		
Number of cases	5	16
Days burn to discharge	67.0	33.3
Percent total burn	47.3	34.6
Percent full-thickness burn	31.3	6.7
Percent mortality	20.0	6.2
Summary		
Number of cases	3748	596
Days burn to discharge	1532.8	860.3
Percent total burn	1226.0	99.9
Percent full-thickness burn	691.6	14.2
Percent mortality	923.2	35.2

NOTE: Based on data collected by The National Burn Information Exchange and covers a seven year period ending in 1971.

SOURCE: Flammable Fabrics, 3rd Annual Report. DHEW Pub. (FDA) 72-7013, Bur. of OF Product Safety, HEW.

NIGHTGOWNS AND PAJAMAS AS A PERCENT OF FIRST FABRICS INVOLVED
AGES 0-6X

FISCAL YEAR	FABRIC CASES 0-6X YEARS	NIGHTGOWN AND PAJAMA CASES 0-6X YEARS	PERCENT
1966-71	73	29	39.7
1966-72	243	74	30.5
1966-73	377	81	21.5

SOURCE: Computed from first and second annual reports of The Consumer Product Safety Commission and annual reports on flammable fabrics, U.S. Department of Health, Education and Welfare.

BEDDING AS A PERCENT OF FIRST FABRIC INVOLVED

FISCAL YEAR	TOTAL CASES IN WHICH FABRICS WERE FIRST ITEM INVOLVED	MATTRESSES FIRST FABRIC INVOLVED	
		CASES	PERCENT
1966-71	529	38	7.2
1966-72	1659	153	9.2
1966-73	2585	167	6.5

SOURCE: Same as above

LIMITATION OF DATA

Appendix-C

"The Fire Department, in its attempt to regain the top rating out of a possible ten, cut fire losses from $3,376,675.00 in 1964 to $2,349,645.00 in 1965. Galotta credited new fire proof clothing that allowed his men to reach previously inaccessible blazes as one of the reasons."

SOURCE: Results of Survey Indicate D.C. to Regain Class One Fire Rating, Washington Post, May 2, 1966, Sec. C., p. 1.

MILITARY TEST FIRES-U.S. and OVERSEAS

Period FY 1964-1969

	Total	Per Year
Number	165	27.5
Fire loss	$158,502	$960/tent
Injuries	34	6

Period FY 1946-1953 (Except Korea)

	Total	Per Year
Number	344	43
Fire loss/tent	$584,800	$1700/tent
Injuries	Not Available	Not Available

SOURCE: Dr. Allan J. McQuade, the U.S. Army Natick Development Center, private communication.

TENT FIRE OCCURRENCES

Year	Tent Fires With Bodily Injury	Tent Fires Without Bodily Injury	Total
1948-1959	1	2	3
1960-1964	1	2	3
1965-1969	8	2	10
1970-1974	45	14	59
Total	55	20	75

SOURCE: Robert F. Johnson and Sally A. Hasselbrack, Textile and Clothing Consumer Studies, University of Minnesota, St. Paul "Flammable Camping Tents--Statistics, Legislation, Testing, and Design" Proceedings of the Eighth Annual Meeting, Information Council on Fabric Flammability, December 1974.

LEGISLATION

Appendix-D

FEDERAL LAWS AND STANDARDS RELATING TO FLAMMABLE TEXTILE MATERIALS

ACTS	COMMENT
Flammable Fabric Act 1953	Regulate highly flammable clothing.
Amended 1967	Range of clothing and interior furnishings; responsibility divided among Secretary of Interior, Secretary of HEW, and FTC.
Consumer Product Safety Act, 1972	Created U.S. Consumer Product Safety Commission with jurisdiction over product safety, responsibility of Flammable Fabrics Act transferred to commission.
STANDARDS	
CS 191-53	General wearing apparel; test procedures; effective July 1, 1954.
DOC FF 1-70	Large carpet and rugs; effective April 16, 1971; carpets of 24 square feet surface area excluding vinyl tile, asphalt tile, and linoleum; test and sampling procedures.
DOC FF 2-72	Small carpets and rugs; effective December 29, 1971; same test as large carpets; labeling requirements on flame retardant rugs and rugs failing test; inherent fibers need not be labeled.
FF 4-72	Mattresses and mattress pads ; effective June 22, 1973; excludes pillows, boxsprings and upholstered furniture; test and sampling procedures; labeling requirement six months on some that could not be treated; treated pads must be labeled.

FEDERAL LAWS AND STANDARDS RELATING TO FLAMMABLE TEXTILE MATERIALS (CON.)

ACTS	COMMENT
DOC FF 3-71	Children's sleepwear sizer 0-6X; effective July 29, 1972; testing and sampling procedures; labeling required on treated and untreated prior to July 29, 1972; sleepwear manufactured after July 29, 1973 must meet standard, labeling voluntary.
FF 5-74	Children's sleepwear sizes 7-14; effective May 1, 1975. Clothing intended primarily for sleeping excluding underwear; sampling plan; labeling on proper care.

STATE LEGISLATION RELATING TO FLAMMABLE TEXTILE MATERIALS

STATE	LEGISLATION	COMMENT
Arkansas	Commission studied and recommendation made to Govenor.	Primary goal of state legislation is for public education in regard to fire and burn prevention. SB 517 would require flame resistant personal and bed clothing for nursing home nonambulatory patients.
Colorado	Legislation passed; Chapter 66 Colo. revised statutes of 1973 amended.	Effective July 1, 1973; Federal Flammability Standard applicable; regulations no less stringent than federal regulations, regulations can be more stringent than federal; Colorado Department of Health Enforcement has authority; develops rules; and regulations and methods of determining flammability of fabrics.
Washington	Legislation passed; substitute House Bill No. 993, an act relating to flammable fabrics.	Effective July 16, 1973; children's sleepwear including size 14, must comply with Federal Children's Sleepwear Standard DOC FF 3-71, 36 F.R. 14062 and Flammable Fabrics Act 15 U.S.C. 1191-1204.
Massachusetts	Legislation passed; general laws amended by inserting Sect. 25D; Sect. 1 Chapter 94B amended. Senate Bill 1580. Department of Health Special Action.	Effective Dec. 1, 1973; children's sleepwear and clothing up to and including size 14; Federal Standard DOC FF 3-71 applicable; Board of Fire Prevention Regulations make rules and regulations; Secretary of Elder Affairs can make and investigate standards for selected elderly clothing; burn injuries from fabric ignition must be reported; public education in prevention and treatment of fabric related burn injuries required. Department of Health action requires labeling of flammable tentage.

STATE LEGISLATION RELATING TO FLAMMABLE TEXTILE MATERIALS (CONTINUED)

STATE	LEGISLATION	COMMENT
Minnesota	House of Representatives making a study of need.	Camping tents and sleeping bags being considered.
Texas	Texas Hazardous Substances Act SB 362; rules and regulations pertaining to all children's clothing up to size 14. Amendment to Hazardous Act introduced Jan. 23, 1973.	Effective July 29, 1973, DOC FF 3-71 for sleepwear size 7-14 and outerwear being promulgated. All children's clothing including size 14 meet Department of Health Flammability Standards. Amendment provides sepcific provisions for flammable fabric control.
California	Flammability of children's clothing, Senate Bill 1011.	After July 1, 1974 sale of children's sleep wear up to and including size 14 is prohibited if Federal Standards not met; by July 1, 1974 state fire marshall shall promulgate flammability regulations for other children's clothing up to and including size 14 which will become effective not later than July 1, 1975.
New Hampshire	Flammable Fabrics Act, House Bill 74; amended Feb. 29, 1972.	Effective May 22, 1972; State Fire Marshall can issue to merchants cease and desist orders on materials representing dangerous fire hazards; penalty $100.00 for each offense, each day represents separate offense. In-store posting of clothing or fabric flammability statement; vendor or manufacturer are liable.
Michigan	Special House Committee established to study unsafe and flammable children's clothing. Act to amend the Public Acts of 1941, House Bill 4169.	Findings and recommendations to be reported to 1973 Legislature. House Bill 4169 effective Oct. 1, 1975, new camping tents must be flame resistant, specification of Canvas Product Association International 84-1972 applicable.

STATE LEGISLATION RELATING TO FLAMMABLE TEXTILE MATERIALS (CONTINUED)

STATE	LEGISLATION	COMMENT
Rhode Island	Legislation introduced.	
Ohio	Legislation introduced.	
Illinois	Flammable Fabrics and Toys Act as amended in 1968.	
New York	Art. 29 General Business Law, June 1969; Chapter 806, Art. 27-D. Pending Product Safety Bill, January 1973, Senate Bill 1565-A, Assembly Bill 1340-A, Senate Bill 9719, Senate Bill 9736, Senate Bill 9737.	Brought state regulations on flammable fabrics into conformity with federal law, effective April 18, 1969; regulates the manufacture sale and movement of flammable fabrics and interior furnishes; established burn centers. Pending legislation State Department of Health responsible for protecting consumers from unsafe products, upgrade and update fabric flammability fabrics, SB 9719 children's sleepwear sizes 7-14, meet federal standards DOC FF 3-71, SB 9736 tent and sleepbags as flammable, SB 9737 require tents and sleeping bags be flame retardant.
Wisconsin		Federal standards adopted; State Department of Agriculture can prohibit by rule any product th at presents flammability hazard.

VERTICAL FLAMMABILITY TESTS: for fabrics and films not expected to burn.

Sponsoring Organization	Name of Test	Idsnt. No.	Spec. Size & Holder (inches)	Ignition Source & Exposure Time	Cabinet size, in.	Conditioning	Properties Measured	Remarks
DOC	Flammability of Children's Sleepwear	DOC FF 3-71	3.5 x 10, 2 x 10 exposed by holder	Yellow Methane flame, 3 sec.	12x12x31	105°C.,30 min.	Char or melt length Residual flame time of material flaming at bottom of chamber.	Flame 25° from vertical. Average char length not to exceed 7 in.; no single one to equal 10 in. Residual flame time not to excsed 10 sec. after removal of ignition flame.
AATCC	Fire resistance of textile fabrics	34-1969	2.75 x 10 2 x 10 exposed by holder	Yellow Matheson B flame, 3 sec. and 12 sec.	12x12x30	70°F., 65%r.h.	Char length, Afterflams, Afterglow	Three fiber-glass seams in specimens of thermoplastic fabrics.
USA	Flame resistance of cloth;Vertical	Method 5903 FTMS 191	2.75 x 12, 2 x 12 exposed by holder	Yellow Matheson B flame, 12 sec.	12x12x30	70°F., 65%r.h.	Char length, Afterflame, Afterglow	
NFPA	Fire Tests - Flame Resistant Textiles and Films, Small Scale	701 Sect. 31 (1969	2.75 x 10, 2 x 10 exposed by holder	Yellow gas flame, 12 sec.	12x12x30	140°F., 1 hr.	Afterflame Char length Flaming of dropped material	Afterflame not to exceed 2 sec.; dropped material not to continue flaming on floor of chamber. Flame 25°from vertical.
UL	Flams Tests of Flame Resistant Fabrics, small scale	UL 214, p.9 (1955)	Same as NFPA	Same as NFPA	Same as NFPA	Same as NFPA	Same as NFPA	Same as NFPA except that angle of flame is not specified.
State of California	Fire Code, Title 19, Small Scale Test	Para.1237.1	2.5x12.5 2x12 exposed by holder	Yellow gas flame, 12 sec.	12x12x30	140°F.,1 hr.	Afterflame Char length	Outdoor material not to exceed 2 sec. afterflame, 6 in. char length. Indoor material not to exceed 1 sec. afterflame, 6 in. char length.
BSI	Flameproof materials	BS 3119:1959	2x12.5, no holder	Yellow gas flame, 12 sec.	12x12x30	70°F.,65%r.h.	Afterflame Afterglow Char-length	B.S. 3120 requires no more than 8 sec. afterflame; no afterglow beyond charred area; average char length not to exceed 3.5 in.
NFPA	Fire Tests - Flame Resistant Textiles and Films, Large Scale	701 Sect. 32 (1969)	5 x 84 and 25 x 84, edges restrained by wires	Gas burner, 11 in. oxidizing flame, 2 min.	12x12x84	140°F., 1 hr.	Afterflame Char length Flaming of dropped material	Char length not to excsed 10 in.above tip of gas flame in 5-in. wide spec.,not more than 35in. in 25in. folded spsc. Dropped material not to continue flaming on floor.
State of California	Fire Code, Title 19, Large Scale test	Para. 1237.2 and 1237.3	5 x 84	Same as NFPA	Same as NFPA	Same as NFPA	Same as NFPA	Same as NFPA, but only 5x84.

VERTICAL FLAMMABILITY TESTS. (Cont'd.)

Sponsoring Organization	Name of Test	Ident. No.	Spec. Size & Holder (Inches)	Ignition Source & Exposure Time	Cabinet Size, In.	Conditioning	Properties Measured	Remarks
UL	Flame Tests of Flame Resistant Fabrics, large scale	UL 214. p.10 (1955)	5 x 84, and 25 x 84, in folds	Same as NFPA	Same as NFPA	Same as NFPA	Same as NFPA	Same as NFPA
State of California	Fire Code, Title 19, Unsupported film, synthetic fabrics, and coated fabrics.	Para. 1273.3	12x30, free-hanging	Gas burner 4-in. oxidizing flame; variable time of exposure.	None	Ambient	Afterflame Char length	Numerous flame applications, including near vertical edges. Afterflame not to exceed 2 sec. No flame to reach top of specimen.
City of New York	Board of Standards & Appeals Rules for Fire-Resistive and Flameproofed Materials, etc.	Cal. No. 294-40 SR Para. 4 and 5	2 x 12.5, free-hanging	Yellow gas flame, 12 sec.	12x12x20	70°F.,40%rh, Specimens whipped in 700 fpm air stream 5 min.	Flashing, Afterflame Afterglow	No flashing, except for fuzzy edges; afterflame not to exceed 3 sec.; afterglow outside of char area not to exceed 20 sec.
City of Boston	Fire Code - 1967 Flammable Decorations	Section 11.07 and 11.08	1.5 x 10, free-hanging	Gas burner 6-in. oxidizing flame, 10 sec.	None	Ambient	Afterflame Afterglow Flaming of dropped material	Afterflame not to exceed 2 sec.; afterglow not to exceed 40 sec. Dropped material not to burn longer than 2 sec. Flame to be raised to keep contact with specimens which melt away.
U.S.A.	Flame Resistance of Cloth; Vertical, Field	Method 5904, FTMS 191	Over 2 x 5; 2 x 5 exposed by holder	Candle flame	None	Ambient	Afterflame Char length Flaming of dropped material	Afterflame not to exceed 2 seconds; char length not over 4.5 in. Dropped material not to continue flaming after reaching floor.
NFPA	Fire Tests - Flame Resistant Textiles and Films, Field Test:Match Flame Test	701 Sect. 51 (1969)	Over 1.5x4, free-hanging	Wooden match flame 12 sec.	None	Ambient	Afterflame Char length Flaming of dropped material	Afterflams not to exceed 2 sec., char length not over 4 in.; dropped material not to continue flame after reaching floor.
General Motors	Fire Resistance Match Method	30-27 (11-13-67)	1 x 12 (not over 0.5 thick) Free-hanging	Wooden match flame, 15 sec.	None	Various, including 158°F. 16 hours	Afterflame Afterglow Char length	Afterflame not to exceed 5 sec., afterglow not over 1 min., char length not over 6 in.
Ford Motor Co.	Flammability Test for Trim Materials	BN 24-1 (1962)	6 x 6	Needle burner, natural gas, 1 min.	Size not specified	Not Specified	Afterflame Afterglow	Flame applied to center of specimen. Afterflame and afterglow requirements not specified.

VERTICAL FLAMMABILITY TESTS, (cont'd.)

Sponsoring Organization	Name of Test	Ident. No.	Spec. Size & Holder (Inches)	Ignition Source & Exposure Time	Cabinet Size, In.	Conditioning	Properties Measured	Remarks
FAA	Airworthiness Standards, Compartment Interiors	Para. 25.853; and Appendix F	4.5 x 12.5, 2x11.5 exposed by holder	Yellow Bunsen flame, 12 sec.	Appropriate size, not specified	70°F., 50%rh	Char length	Average char length not to exceed 8 in.
CGBS	Flame Resistance - Vertical Burning Test	Standard 4 - GP-2, Method 27.1 (1960)	2 x 12.5 Free hanging	Yellow Bunsen flame, 12 sec.	12 x 12 x 30	Not specified	Flashing Afterflame Afterglow Char length	No flashing to occur; average afterflame not to exceed 2 sec.; afterglow not to extend beyond char area; char length not to exceed 3.5 in.
FRANCE	Decret 57-1161 (revised 1965) Determination de la combustibilite	Tit. II, Chap. II, Sect. I	24 x 30 cm., supported on pins, edges not shielded	Ethanol flame, 3 min.	None	Not specified	Smoke, Char length, Afterflame	

SOURCE: Proceedings of the Fifth Annual Meeting, Information Council on Fabric Flammability, Dec. 9, 1971

RATE-OF-BURN TESTS: with specimen held at 45° angle.

Sponsoring Organization	Name of Test	Ident.No.	Spec. Size & Holder (Inches)	Ignition Source & Exposure Time	Cabinet Size, In.	Conditioning	Properties Measured	Remarks
USA	Flammability of Clothing Textiles	CS-191-53	2 x 6, 1.5 x 6 exposed by holder	Butane microburner, 1 sec. Ignited on surface, above lower edge	8.5x14.5x14	221°F.,30 min.	Time for 5-inch flame spread. Ease of ignition Flame intensity	Class 1,"normal flammability", napped fabrics: flame spread time over 7 sec., or surface flash not igniting base fabric. Plain fabric: over 3.5 sec.
USA	Burning rate of cloth; 45° angle	Method 5908 FTMS 191	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	
AATCC	Flammability of Clothing Textiles	33-1962	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	
ASTM	Flammability of Clothing Textiles	D-1230-61	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	
NFPA	Flammability of Wearing Apparel	702-1963 Chap. 4.	Same as CS-191-53	1-sec. exposure for napped fabrics; forced ignition for plain fabrics. Plain fabrics ignited at lower edge.	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	NFPA Class 1 has flame spread time of 20 sec. or more; Class 2: 8 to 19 sec., and Class 3: 3 to 7 sec. Class 4: rapid-burning, under 3 sec.
Switzerland	-------	SNV 98896 SNV 98899	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	
BSI	Flammability of fabrics	BS 2963-1958, Method B	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Same as CS-191-53	Used for fabrics with flame ratings less than 100 (by Method A, BS 2963)
CGSB	Flame Resistance - Surface Burning Test	4-GP-2 Method 27.2	6 x 7, 6 x 6 exposed by holder	Absolute ethanol flame; 50 sec.; applied to under side at center.	12x12x30	221°F., 30min.	Afterflame, Afterglow, width of charring across upper edge	"Moderately flame resistant" fabric to have not over 2 in. char across upper edge; not over 15 sec. afterflame plus afterglow, Method not applicable to fusible fabrics.

RATE-OF-BURN TESTS: with specimen vertical.

Sponsoring Organization	Name of Test	Ident.No.	Spec. Size & Holder (Inchee)	Ignition Source & Exposure Time	Cabinet eize, in.	Conditioning	Properties Meaeured	Remarks
NFPA	Flammability of Wearing Apparel, non-textile	702-1963 Chap. 5	2 x 12, free-hanging	Yellow Bunsen flame; 10 eec.	Draft-free encloeure	Not epecified	Time for flame to reach upper edge	Normal flammability: more than 10 sec. for flame to reach upper edge of specimen.
CGBS	Flame Reeistance - Rate-of-burning Test	4-GP-2 Method 27.3	2 x 30, free-hanging	Microburner, forced ignition	12x12x48	221°F., 30min.	Time for flame to travel 25 in.	Rate-of-burn over 1.5 in/sec. considered hazardoue; lees than 0.75 in/sec. considered elow-burning.
BSI	Flammability of fabrics	BS 2963-1958, Method A	1.5 x 72, free-hanging	Yellow Bunsen flame, 12 sec.	None (draft-free room)	68°F.,65%rh	Time for flame to travel 50 in.	Flame rating equals double the time required for 50-in. flame propagation.

RATE-OF-BURN TESTS: with specimen horizontal.

Sponsoring Organization	Name of Test	Ident. No.	Spec. Size & Holder (Inchee)	Ignition Source & Expoeure Time	Cabinet Size, in.	Conditioning	Properties Measured	Remarks
DOT	Flammability of Vehicle Interior Materials	MVSS 302	4x14, 2x13 exposed by holder	Yellow Bunsen flame 15 eec.	8x15x14	70°F.,65%rh	Time for flame to travel 10 in.	Napped fabrics combed against the nap.
USA	Burning rate of Cloth, Horizontal	Method 5906 FTMS 191	12.5 x 4.5, 12 x 2 exposed by holder	Yellow Bunsen flame, 15 eec.	8x15x14	140°F.,4hrs. Teet cabinet at 140°F.	Time for flame to travel 10 in.	Fabrice which eoften with heat are supported by croeswires at 1 in. intervals.
FAA	Airworthiness Standards, Compartment Interiore	Para. 25.853 & Appendix F	12.5 x 4.5, 11 x 2 expoeed by holder	Yellow Buneen flame, 15 sec.	Suitable Size	70°F.,50%rh	Char length, or time to travel 10 in.	Outer suface of fabric muet be face down in the test.
France	Speed of flame propagation	Decret 57-1161 (revised 1965) Tit.II,Chap.II Sect. II	40 x 3.5 cm.	3-cm. flame	None	Not specified	Time for flame to travel 25 cm.	

OTHER TEST METHODS

Sponsoring Organization	Name of Test	Ident.No.	Spec. Size, Holder and Position	Ignition Source & Exposure Time	Cabinet or Chamber Size	Conditioning	Properties Measured	Remarks
ASTM	Surface Burning Characteristics of Building Materials	E 84-68	20 in. x 25 feet Horizontal, with specimen on roof of chamber	4.5 foot gas flame, 10 min.	17.5 in. wide, 12 in. high, 25 feet long	70°F. 40%rh	Flame spread in 10 min., smoke density, fuel contribution	Red oak flooring speads flame 19.5 feet in 5.5 min.
ASTM	Surface Flammability of Materials Using Radiant Energy Heat Source	E 162-67	6 in. x 18 in.	12 in. x 18 in. panel, at 670°C. 15 min.	-----	73°F., 50%rh	Flame spread smoke density surface flash	
DOC	Carpet Flammability	DOC FF-1-70 DOC FF-2-70	9 in. x 9 in. 8 in. diam. area exposed Horizontal	Methenamine tablet	12 in x 12in. x 12 in.	221°F., 2 hrs.	Distance of char from 8-in. circle.	Char not to come within 1 inch of 8-in. circle in more than one out of eight tests. Treated carpet to be washed 10 times before testing.
ASTM	Flammability of Finished Textile Floor Covering Materials	D 2857-70T	Same as DOC-FF-1-70	Same as DOC-FF-1-70	Same as DOC-FF-1-70	Same as DOC-FF-1-70	Same as DOC-FF-1-70	
USA	Carpets and Rugs	DDD-C-95, Sect.4.5.13	6 in. x 6 in. Horizontal	Methenamine tablet	12 in. x 12 in. x 9 in.	94°F., 30%rh	Diameter of charred area	Diameter of char not to exceed 2 inches.
CGSB	Carpets, Tufted, for Residential Use	4-GP-76b, Sect. 6.3.6	Same as DDD-C-95	Same as DDD-C-95	Same as DDD-C-95	Same as DDD-C-95	Same as DDD-C-95	Same as DDD-C-95
USA	Carpet, Aircraft	MIL-C-7176D	6.75 in.x 27 in. Horizontal	Burners	-----	Ambient	Area of Flame Spread	
CGSB	Combustion Resistance of Mattresses: Cigarette Test	35-GP-1	18 x 18 in. spec. mattress; cut ticking 15 x 15	3 cigarettes	Fume cupboard, with fan off	122°F., 5 hours	Ignition of mattress or covering.	Outer covering (ticking) is leached and dried before testing. Mattress itself is not leached.
CGSB	Flame Resistance - Ease-of-Ignition Test	4-GP-2, Method 27.4	7 in. x 7in., 6 in. x 6in. exposed by frame; horizontal	Yellow microburner flame applied from beneath the specimen	12x12x30	221°F., 30 minutes	Ignition after various flame exposure times	Ignition at flame exposure time of 2.0 sec. or less considered easy to ignite.
USA	Burning Rate of cloth; 30° angle.	Method 5910, FTMS 191	1 in. x 6 in., supported on 3/8 in. spaced crosswires.	Paper match	None	140°F., 4 hrs.	Time to burn 6 in. Char length Afterflame	

PROPOSED NEW TESTS.

Sponsor	Name of Test	Ident.No.	Specimen Size & Holder	Angle of Spec.	Ignition Source	Conditioning	Properties Measured	Remarks
USA	Flame Resistance of Material; High Heat Flux Flame Contact	Method 5905, FTMS 191	2.75 x 12 in. free-hanging by crucible tongs	Vertical	Fisher Burner 3-in. oxidizing flame	Ambient	Char length Melting Percent Consumed	Burner held horizontally for specimens which melt.
DOC	Proposed flammability standard for mattresses.	DOC PFF-4-71	Full-size mattress or mattress pad	Horizontal	18 cigarettes	Test room to be below 55% rh. Treated mattresses to be leached with 2 gal. water per foot of width, then dired 48 hours.	Ignition Char length	All smoking is to stop within 5min.after cigarette has burned out.Char length on surface to be less than one inch in any direction from cigarette. Mattress pads to be laundered and dried 25 times before testing.
CGBS	Rate of Burning of Consumer-Type Textiles (Vertical Strip Test)	108-GP-1P	5 in.x30in., 2 in.x30in. exposed by holder	Vertical	Microburner, 0.5 in.flame	105°C.,30min.	Time for flame to travel 25 in.	Specimens containing more than 50% thermoplastic fibers are sewn lengthwise with 3 fiber-glass seams.
Miller and Meiser(TRI)	Wheel-feed Flame Propagation Test	Textile Chem. & Col, Vol., 3, p. 118 (1971)	At least 1.5 in. wide, held on two-wheel holder.	Any angle can be used.	Microburner	Variable	Burning rate at constant angle of specimen; wheel rotates so as to keep flame front stationary in space.	Apparatus also adapted to measure burning rate at various oxygen contents of gas mixture.
Japan	SB Flammability Test	------	7 x 70 cm.	Part vertical, part half-hoop	Microburner	105°C., 2hr.	Char length	Six flammability ratings, depending on char length.
FNM	Determination of the Burning Behavior of Combustible Textiles - Semi-circle Tester	DIN 54 331	65 mm x 475 mm, held in half-hoop holder	0 to 180°, in half-circle	Propane Flame,15sec.	20°C.,65%rh	Afterflame Time to burn to 90° Angle of burning Angle burned in 15 sec. Afterglow	
Michigan Chem. Corp.	Oxygen Index Tester/Smoke Densitometer	------	2 x 6 in.	Vertical, burning from top down.	Propane flame	Variable	Percent of oxygen in atmosphere needed to maintain combusion. Smoke density	
State of California-Dept. of Consumer Affairs - Bureau of Furniture & Bedding Insp.	Flammability Standard for Mattresses, Mattress Covers & Bulk Filling Materials	No number Dated Oct., 1971	Mattress: Full size Cover: 2.75x10 in. with 2x10 exposed Filling: 2x10in. 0.5 to 1.0 in. thick; no holder	Mattress:Horizontal Cover and Filling:vertical	Mattress:cylindrical metal heater,1000°F. 5 min. Cover &Filling: yellow gas flame	Mattress: 70°F., max. 60% rh Cover and Filling: 70°F., 65% rh	Mattress:ignition and char length; Cover & Filling afterflame,afterglow, char length	Mattress: there is to be no ignition; char length 2 in. max. Cover: max. av. afterflame 3 sec.,afterglow 10 sec; char length 5 in. Filling: max.av.afterflame 5 sec.;afterglow 5 sec., char length 6 in.

KEY TO ABBREVIATIONS USED IN TABLES OF TEST METHODS

AATCC -- American Association of Textile Chemists and Colorists
P.O. Box 12215
Research Triangle Park, N. C. 27709

ASTM -- American Society for Testing and Materials
1916 Race Street
Philadelphia, Pa. 19103

BSI -- British Standards Institution
2 Park Street
London W1A 2BS, England

CGSB -- Canadian Government Specifications Board
c/o Department of Supply and Services
9th Floor, 88 Metcalfe Street
Ottawa, Canada

DOC -- U.S. Department of Commerce
National Bureau of Standards
Washington, D. C. 20234

DOT -- U.S. Department of Transportation
Washington, D. C. 20590

FAA -- Federal Aviation Administration
800 Independence Ave., S.W.
Washington, D. C. 20590

FNM -- Fachnormenausschuss Materialprufung
46 Dortmund . Hakenstrasze 5
Germany

FTMS -- Federal Test Method Standard
Obtainable from: General Services Administration
Specifications Activity
Building 197, Naval Weapons Plant
Washington, D.C. 20407
Also obtainable from other offices of the GSA.

MVSS -- Motor Vehicle Safety Standard

NFPA -- National Fire Protection Association
60 Batterymarch Street
Boston, Massachusetts 02110

SNV -- Swiss Standards Association

TRI -- Textile Research Institute
Princeton, N. J.

UL -- Underwriters' Laboratories, Inc.
333 Pfingsten Road
Northbrook, Illinois 60062

USA -- U.S. Government, test methods used for government purchases

OTHER SOURCES OF SPECIFICATIONS AND TEST METHODS

Federal Register: obtainable from Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402, at 20¢ per copy.

California State Fire Marshal
1215 O Street
Sacramento, Calif. 95814

California Department of Consumer Affairs
Bureau of Furniture and Bedding Inspection
3401 Lagrande Blvd.
Sacramento, Calif. 95823

Boston Fire Department
Fire Prevention Division
115 Southampton Street
Boston, Mass. 02118

New York City Board of Standards and Appeals
80 Lafayette Street
New York, New York

Standards of all types, including those of foreign countries, are available from:

American National Standards Institute, Inc.
1430 Broadway
New York, New York 10018

SOURCE: Proceedings of the Fifth Annual Meeting, Information Council on Fabric Flammability, December 9, 1971.

THE STATE OF FR TECHNOLOGY

Appendix-E

Market	Fiber	Finish	Chemical Nature	Company	Strong Points	Remarks
Apparel	Cotton or Rayon	Pyrovatex CP (1)	N-methylol dimethyl phosphonopropionamide	Ciba-Geigy Corp.	Durable to over 50 L & TD; Soft Handle	Relatively high strength losses
		THPC finishes (2, 3, 4)	Tetrakis (hydroxymethyl) phosphonium chloride	Hooker Chemical Co.	Durable to over 50 L & TD	Problems with hand and strength losses
		THP chloride (2)	Tetrakis (hydroxymethyl) phosphonium chloride	Albright & Wilson (U.S. agent is Aceto Chem. Co.)	Similar to THPC	Similar to THPC
		Pyroset TKC (2,5)	Tetrakis (hydroxymethyl) phosphonium chloride	American Cyanamid Co.	Similar to THPC	Similar to THPC
		Pyroset TKP (5,6)	THP salt with mixed phosphate and acetate anions	American Cyanamid Co.	Similar to Pyroset TKC	Problem with hand
		Pyroset TKS (5)	THP salt with organic anion	American Cyanamid Co.	Similar to Pyroset TKC; Softer hand	Relatively high strength losses
		Proban (7, 19)	THP salt-urea pre-condensate	Albright & Wilson (U.S. agent is Ventron Co.)	Soft handle; Good strength retention	Requires special ammoniating equipment
		THPOH-NH_3 (8)	THP Salts at a pH of about 7	All of above manufacturers of THP Salts	Soft handle; Good strength retention	Requires special ammoniating equipment
		MCC 100/200/300 (9, 10)	Trimethyl phosphoramide	Monsanto Co.	Durable to 50 L & TD	Stiff hand; semi-commercial
		Fyrol 76 (11)	Condensate of bis (beta-cloroethyl) vinyl phosphonate	Stauffer Chemical Co.	Durable to over 50 L & TD; Some DP properties	
		DAP-Urea-Ti(26)	Obvious	Various	Low cost; Durable to over 50 L & TD	Uses aqueous titanyl sulfate
	Wool	THP Salts	(see above)	(see above)	Durable to laundering and dry cleaning	
		Proban (12)	(see above)	(see above)		
		Multi-Krome 13,14)	Mordanting with Cr, Ti, or Zr Salts	Various		

Textile Finishes (Con't.)

Market	Fiber	Finish	Chemical Nature	Company	Strong Points	Remarks
Apparel	Polyester	Apex Emulsion 462-5 and 567 (15)	tris (2,3-dibromo propyl)phosphate	Apex Chemical Co.	Durable to over 50 L & TD	Less durable to dry cleaning; some UV instability
		Hamcogard FR	tris (2,3-dibromo propyl) phosphate	Hamilton & Auslander Co.	Durable to over 50 L & TD	Less durable to dry cleaning; some UV instability
		Fyrol 59	tris (2,3-dibromo propyl) phosphate	Stauffer Chemical Co.	Durable to over 50 L & TD	Less durable to dry cleaning; some UV instability
		Tanotard PN-2	tris (2,3-dibromo propyl) phosphate	Chas. S. Tanner Co.	Durable to over 50 L & TD	Less durable to dry cleaning; some UV instability
		Glo-tard PE-2 and PE-10	tris (2,3-dibromo propyl) phosphate	Glo-Tex Chemicals Inc.	Durable to over 50 L & TD	Less durable to dry cleaning; some UV instability
		Cav-Gard FR-1811 and FR-1812	tris (2,3-dibromo propyl) phosphate	Cavedon Chem. Co.	Durable to over 50 L & TD	Less durable to dry cleaning; some UV instability
	50/50 and 65/35 P/C blends	Pyrovatex 3762 (17)	Oligomer of THP Chloride	Ciba-Geigy	Durable to over 50 L & TD	Stiff hand; developmental product
		F/R P-44 (27)	DBDPO and antimony oxide	White Chem. Co.	Durable to 50 L & TD; No strength loss	Problems with hand for some end uses
	Reverse blends of polyester and cotton	THP Salts (5, 16)	(see above)	(see above)		Stiff hand
		F/R P-44 (27)	(see above)	(see above)	(see above)	(see above)
Sheets and bedclothes	All	Same as apparel				
	Cotton and reverse blends	Flame snub WDN	Phosphorus compound	Arkansas Co.	Durable to over 50 L & TD	
Drapery and Upholstery Fabrics	Cellulosics	Same as apparel if extensive resistance to both laundering and drycleaning is desired				
		LRC-6 (28)	DAP-Urea-PVC-Sb_2O_3	Various	Low cost	Not durable to very hard water
		Fi-Retard NBX	Inorganic salts and nitrogen	Arkansas Co.	Semi-durable to dry cleaning	

Textile Finishes (Con't)

Market	Fiber	Finish	Chemical Nature	Company	Strong Points	Remarks
Drapery and Upholstery Fabrics (Con't)		Pyroset CP (18)	Cyanamide and phosphoric acid	American Cyanamid	Low cost; durable to dry cleaning	Semi-durable to laundering; Strength loss
		A number of water-soluble non-reactive organic and inorganic compounds	Various, such as phosphate salts and esters, sulfamates, sulfates, dicyandiamide, borax-boric acid, borophosphates, etc.	Arkansas Co., Apex Chemical Co., Laurel Products Co., U.S., Borax, etc.	Low cost	Not durable to laundering; resistance to dry cleaning
	Wool	Same as for wool apparel				
	Polyester	Same as for polyester apparel				
	Nylon	Nyloset	Thiourea-formaldehyde derivative	Scher Bros. Inc.	Low cost	Rather stiff hand; Semi-durable to laundering
		Nylo-Gard FR	Thiourea-formaldehyde derivative	Hamilton-Auslander Co.	Low cost	Rather stiff hand; Semi-durable to laundering
		Celluset (15)	Thiourea-formaldehyde derivative	Apex Chem. Co.	Low cost	Rather stiff hand; Semi-durable to laundering
	Polyester/ cotton blends	Same as for polyester/cotton blends for apparel				
Industrial and military fabrics	Cotton or rayon	THP Salts (20)	THP Salts	Hooker, American Cyanamid, Albright & Wilson	Durability to laundering	Some hand and strength loss problems
		FWWMR (20, 21)	Sb_2O_3, chlorinated paraffins, etc.	Various	Fire, weather, mildew, rot, and water resistant	Stiff hand
		LRC-6 (28)	DAP, urea, Sb_2O_3, PVC	Various	Low cost	Not durable to very hard water

. Textile Finishes (Con't)

Market	Fiber	Finish	Chemical Nature	Company	Strong Points	Remarks
Industrial and military fabrics	Wool	Multi-Krome (13, 14)	Mordanting with Cr, Ti or Zr Salts	Various		
Carpet	Cotton or rayon	THP Salts (22)	THP Salts	Hooker, American Cyanamid, Albright & Wilson	Meets FF 1-70 and 2-70	
		Pyroset CP (22)	Cyanamide and phosphoric acid	American Cyanamid	Meets FF 1-70 and 2-70	
		MCC 100/200/300 (9)	trimethyl phosphoramide	Monsanto Co.	Meets FF 1-70 and 2-70	
	Wool	Multi-Krome (20, 21)	Mordanting with Cr, Ti, or Zr	Various	Meets FF 1-70 and 2-70	
		Pyroset CP (23)	Cyanamide and phosphoric acid	American Cyanamid	Meets FF 1-70 and 2-70	

SOURCE: LeBlanc, R. Bruce. What's Available for Flame Retardant Texiles. Textile Industry Vol. 139, No. 2, Feb. 1975.

Both large and small chemical companies claim a piece of the action in flame retardants

Major suppliers	Flame-retardant chemicals							Major end uses for flame-retardant chemicals										
	Antimony oxide, antimony compounds	Inorganic salts[a]	Chlorine compounds	Bromine compounds	Phosphorus and/or nitrogen compounds[b]	Proprietary	Other	Cotton, silk, wool, linen	Paper, wood products	Cellulosics[c]	Noncellulosics[d]	Polyurethane	Polystyrene	Polyolefins	Epoxies, polyester resins	Polyvinyl chloride, other vinyls	Latex, rubber, adhesives	Acrylonitrile-butadiene-styrene	Other
Alcoa							●										●		
American Cyanamid					●		●		●		●	●							
Apex Chemical		●				●			●		●	●							
Arkansas		●				●			●		●		●						
Chemetron Corp.	●								●	●					●	●	●	●	
Ciba-Geigy					●				●		●	●							
Diamond Shamrock			●												●				●
Dover Chemical			●												●	●	●		●
Dow Chemical		●		●	●						●		●	●	●	●	●		
Du Pont		●				●			●	●	●								
Finelex						●			●	●									
FMC Corp.					●										●	●			●
Freeman Industries				●							●		●	●		●			
B. F. Goodrich			●				●									●	●		
Great Lakes Chemical				●						●	●		●	●	●	●	●		●
Hart Products		●			●				●		●								
Hooker Chemical	●		●		●				●	●	●	●	●	●		●		●	●
Humphrey Chemical		●	●						●	●	●				●	●	●	●	●
ICI America			●		●								●			●			●
Interplastic Corp.			●																●
Jersey State Chemical																			
Laurel Products		●			●				●		●	●							
M&T Chemicals	●						●		●	●					●	●	●	●	
Michigan Chemical	●			●	●				●	●	●		●	●	●	●	●	●	●
Monsanto		●	●		●	●			●	●	●		●		●	●	●		●
Neville Chemical			●														●		●
National Starch & Chemical	●		●							●							●	●	
NL Industries	●														●	●	●		●
Scher Brothers		●			●		●		●		●	●							
Scholler Brothers				●					●										
Selig Chemical		●							●		●								
Seydel Wooley		●							●										
Stauffer Chemical		●			●	●			●	●	●	●	●	●		●	●		●
Sun Chemical		●			●				●		●								
Swift Chemical				●	●								●						
U.S. Borax & Chemical		●													●				
U.S.I. Chemicals							●							●					
White Chemical				●						●	●			●		●		●	

[a] Includes zinc borates, but excludes antimony compounds. [b] Includes phosphate esters. [c] Rayon, acetate, triacetate. [d] Acrylic, anidex, glass, modacrylic, nylon, olefin, polyester, rubber, saran, spandex, vinyon. [e] Jersey State formulates wide variety of flame-retardant compounds to meet specific customer needs.

Note: Table is not intended to be all-inclusive. It includes major suppliers of flame-retardant chemicals and the major end uses for the compounds. Other end uses are also possible other than those listed.

TABLE Flame Retardant Fibers

Fiber	Company	Chemical Nature	Composition of Fabrics	Comments and Major Markets
Acele FLR	Du Pont	Acetate with TDBPP additive (24)	100% acetate and blends with up to 20% polyester	Apparel
FR Acetate	Celanese	Acetate with TDBPP additive	100% acetate and blends with up to 20% polyester	Apparel
SayFR	FMC	Acetate with TDBPP additive (24)	100% Acetate and blends with up to 20% polyester (25)	Apparel
Arnel FR	Celanese	Triacetate with TDBPP additive	Blends with polyester	Apparel
Dacron 900F (29)	Du Pont	Polyester copolymer with ethoxylated tetrabromobisphenol A	100% Polyester and blends with certain fibers	Apparel; Development product
HEIM (30)	Toyobo Co.	Polyester containing aromatic, sulfur-containing phosphonate	100% Polyester and blends with certain fibers	Drapery; Semi-commercial
Extar FR	Teijin Co.	Bromine containing polyester		Developmental product
Orlon FLR	Du Pont	Modacrylic		Developmental product
SEF (31)	Monsanto	Modacrylic	100% SEF and blends with acrylic or polyester	Apparel, drapery, and industrial fabrics
Verel	Eastman	Modacrylic	100% Verel and blends with rayon or acrylic	Apparel, home furnishings
Teviron	Teijin	Vinyon	100% Vinyon and blends	Apparel, home furnishings
Leavil (32)	Montedison	Vinyon	100% Vinyon and blends	Apparel, home furnishings
Clevyl T	Rhone-Poulenc	Vinyon	100% Vinyon and blends	Apparel, home furnishings

TABLE Flame Retardant Fibers (Con't)

Fiber	Company	Chemical Nature	Composition of Fabrics	Comments and Major Markets
Valren (33)	Teijin	Vinyon	100% Vinyon and blends	Apparel, home furnishings
Cordelan	Kohjin Co.	Vinal-Vinyon Matrix	100% Cordelan and blends with up to 20% of cotton or polyester	Apparel, home furnishings
Avril PFR	FMC	Rayon with a Phosphazene derivative added	100% Rayon and blends with fibers such as Nomex	Safety apparel, aircraft upholstery and others; Developmental product
Bell Flame FR	Kanebo Co.	Rayon with FR additive		Developmental product
Wool		Protein	100% Wool and blends with Fiberglas, Vinyon, Nomex, etc.	Apparel, industrial work clothes, aircraft upholstery and others
Fiberglas	Owens-Corning	Glass	100% Fiberglas and blends	Drapery, industrial work clothes, and others
Nomex	Du Pont	Aramid (Aromatic Nylon)	100% Nomex and blends with Kynol, Wool, etc.	Apparel, industrial fabrics, airline upholstery, specialty products
Kynol (34)	Carborundum	Novoloid	100% Kynol and blends	Industrial fabrics; semi-commercial product

SOURCE: LeBlanc, R. Bruce. What's Available for Flame Retardant Textiles. Textile Industry Vol. 139, No. 2., Feb., 1975.

PROGRESS TOWARD OBJECTIVES

Appendix-F

Contributions to Scientific Knowledge

PROJECTS ON FIRE RESEARCH

	TOTAL PROJECTS	TEXTILE PROJECTS			
		TOTAL	ARS	OTHER U.S.	INDUSTRY
1965-67	557	9	0	6	3
1967-69	1201	32	4	20	8
1969-71	204	31	11	16	4
1971-73	376	47	19	24	4

SOURCE: DIRECTORY OF FIRE RESEARCH IN THE UNITED STATES. THE COMMITTEE ON FIRE RESEARCH OF THE DIVISION OF ENGINEERING, NATIONAL RESEARCH COUNCIL.

TEXTILE FLAMMABILITY REFERENCES

	NUMBER	ACCUMULATED
1964	7	16
1965	8	24
1966	5	29
1967	26	55
1968	39	94
1969	50	144
1970	107	251
1971	144	395
1972	176	571
1973	177	748
1964-73	739	2327

SOURCE: Textile Technology Digest.

SUBJECT PROFILE OF REPORTS ON TEXTILE FLAMMABILITY
1964 vs. 1973[1/]

	1964	1973
Standards & Regulation	0	43
Testing & Measurement	3	36
Carpets	0	6[2/]
Mattresses	0	2[2/]
Upholstery	0	0[2/]
Sleepwear	0	2[2/]
Other	6	88
TOTAL	9	177

1/ Reports on flameproofing compounds and other flammable materials other than textiles are excluded.

2/ These categories are also covered in the standards, regulation, testing and measurement subject areas.

SOURCE: Textile Technology Digest.

TECHNICAL PUBLICATIONS AND PATENTS RELATING TO TEXTILE FLAME RETARDANCE, SRRC, 1964-1974

	PUBLICATIONS			PATENTS
	NUMBER	REPRINT NUMBERS	REPRINT PAGES NUMBER	NUMBER
1964	4	2,450	13,950	1
1965	3	1,450	6,700	1
1966	8	2,482	27,410	2
1967	7	2,025	11,325	4
1968	7	2,600	10,900	2
1969	16	3,500	19,400	1
1970	23	5,175	28,750	2
1971	23	3,450	14,150	5
1972	34	4,302	41,185	4
1973	20	3,300	19,100	4
1974	20	2,700	18,700	7
1964-73	146	30,734	211,572	25

JOURNALS USED FOR DISSEMINATION OF FLAME RETARDANT RESEARCH DEVELOPMENTS, SRRC, 1964-1974

	NUMBER OF JOURNALS	FREQUENCY OF USE	
		SINGLE ARTICLE	MULTIPLE ARTICLES
1964	4	4	0
1965	3	3	0
1966	7	6	1
1967	5	4	1
1968	7	7	0
1969	9	6	3
1970	12	6	6
1971	9	4	5
1972	13	5	8
1973	9	3	6
1974	8	3	5

SELECTED TECHNICAL ACCOMPLISHMENTS OF THE FLAME RETARDANT PROGRAM, SRRC, 1964-1973

	NUMBER OF[1/] ACCOMPLISHMENTS
1964	5
1965	2
1966	5
1967	6
1968	9
1969	9
1970	10
1971	18
1972	18
1973	18
1964-73	100

1/ Individual accomplishments are described F-7 through F-12.

SELECTED TECHNICAL ACCOMPLISHMENTS OF THE FLAME RETARDANT PROGRAM
SRRC, 1964-1973

1964

Reaction mechanism for important aziridine ring chemistry.

Generalized application method for APO/Thpc for cotton fabrics.

Process for making aziridinyl-N-alkyl phosphonic amides.

Application process for aziridinyl-N-alkyl phosphonic amides.

Prepared new compound N,N'-ethylene bis /P,P-bis(1-aziridinyl)-N-methylphosphinic amide/.

1965

Synthesized new phosphorous-containing crosslinking agents.

Spray technique for FR application to cotton pile and nap fabrics.

1966

Determination of APO/Thpc mole ratio on FR durability.

Development of thermal data on degradation of FR cotton fabrics.

Prepared polymers from methylol phosphorus and diisocyanate compounds for FR.

Polymerization of P and N containing materials with NH_3.

Pad-dry-cure technique applied to duck using APO/Thpc formulations.

1967

New chemical cure used on THPOH-NH_3 treated lightweight fabrics.

Aqueous emulsions of polyvinyl chloride applied to cellulosic textiles.

Aqueous emulsions of methyl hydrogen polysiloxane applied to cellulosic textiles.

Aqueous emulsion of zirconium acetate applied to cellulosic textiles.

Use of methylolated halo-cyano acid amides as textile FR.

Use of (perflorodioxycycloakyl)triphenyl phosphonium betanes as FR.

1968

Developed simple heat cure for modified THPOH-amide treatments.

Eliminated methanol from the THPOH-NH_3 process.

Synthesized some bis(halo-methyl)phosphorylmethyl-triphenyl phosphonium halides.

Synthesized a stable phosphine methylene.

Developed Thpc-phosphoroxytriamide as a FR.

Developed Thpc-dimethylamidophosphoroxydiamide as a FR.

Developed Thpc-tris(carbamoylethyl)phosphine as a FR.

Developed Thpc-tris(carbamoylethyl)phosphine oxide as a FR.

Developed flame retardant cotton flote.

1969

Trimethylolmelamine used in THPOH-NH_3 pad bath.

Feasibility of using N-methylol agents in THPOH-NH_3 processes.

Copper salts used to stabilize THPOH-NH_3 hydroxide solutions.

Single bath procedure without use of gaseous ammonia developed for THPOH-NH_3.

Determined heat cure more resistant than chemical cure to micro-organism attack.

Evaluated chemistry involved in conversion of Thpc to THPOH.

Phosphorous replaced by trimethylolmelamine in THPOH-copper nitrate-ammonium hydroxide bath.

Developed oxidation procedure for THPOH-ammonia process.

Demonstrated that different nitrogen and phosphorus types influenced FR effectiveness.

1970

2-Amino,4,6-bis(diethoxyphosphonyl)-1,3,5-triazine can be used for moderate FR.

Verified the structure of polymers formed by THPOH reaction with polyfunctional amines.

Developed process for bis-(sulfatomethyl)phosphinic acid.

Developed test controls for the vertical flame test.

Structures for the reactive species of THPOH elucidated.

Alkyl(amino-s-trizinyl)phosphonates preparation procedure developed.

Defined parameters for photochemical and thermal degradation of FR.

Cotton crosslinked with haloalkyl phosphine oxides.

Developed flame retardant cotton batting.

Developed flame retardant multiple density cotton batting.

1971

Developed Thpc finish formulations with urea and methylolmelamine.

Demonstrated that phosphorus content and flammability effected by laundering conditions, water hardness and types of detergents.

Developed Thpc or THPOH based treatments for selected knit fabrics.

Tertiary phosphines in methylolphosphonium salts can be displaced by tributylphosphine.

Determined the effect of temperature on the oxygen index value.

Formaldehyde derivatives from 2,4-diamino-6-diethoxyphosphinyl-1,3,5-triazine were developed.

Some finish stability could be obtained by oxidation with hydrogen peroxide.

Halogenated oxirane can be used as a fire retardant on diethylaminoethyl cellulose.

Developed new process for preparation of haloalkyl phosphinic acids.

Developed method for identifying fluorochemical finishes.

Methods for flame retarding cotton tufted rugs developed.

Instrumental methods developed for evaluating smoldering combustion.

Developed application equipment for flame retardant cotton batting.

Demonstrated that moisture control is essential for use in oxygen index testing.

Formaldehyde effects the reaction between tris(hydroxymethyl)-phosphine and diphenylamine.

Develop preparation process for bis(halomethyl)phosphoryl methyl triphenylphosphonium halides.

Patentable THPOH-ammonia process developed.

Solutions containing organophosphorus compounds developed as a fire retardant.

1972

Defined the reactions of THPOH with model compounds.

The stability of phosphorus based FR to sunlight improved by use of pigment-binding agents.

Suggested explanation for the synergistic effect of P-N during the pyrolysis of FR cotton.

Defined the effect of fabric weight and construction on oxygen index values.

Established optimum pH values for Thpc-cyanamide retardants.

Delineated the environmental temperature effects on OI values.

Synthesized several phosphonoadipates and phosphonoadipamides.

Cotton flameproofed with hexamethylphosphorus triamide.

Developed method for the determination of water in cotton.

Retardant developed with bis(chloromethyl)phosphorylmethyl tirphenylphosphonium halides.

IR spectroscopy used to identify flame retardant.

Defined atmosphere and additives effects on free radical and char formation during thermolysis.

Determined cotton cellulose reactions with phosphorus trihalide-dimethyl formamide systems.

Method for reducing formaldehyde odor in Thpc systems developed.

Demonstrated that mixed catalyst improves durability of Thpc-amide finishes.

Defined the effects of moisture on standard test methods.

Glycolurils improves wrinkle resistants of Thpc-amide finish.

Flame resistant thermo setting polymers can be obtained from Thpc compounds and isocyanates with or without N additives.

1973

Thpc with urea can be catalyzed with sodium phosphate salts.

Increased the efficiency of reactants in THPOH amide treatments with acidic catalyst.

Demonstrated the effect of dyes on FR fabrics.

Synthesized tris(N,N-dimethyl-Z-carbamolyethyl)phosphine oxide.

Demonstrated the effects of UV and high temperatures on FR.

Dimethylol cyanoguanidine can be added to Thpc systems.

Phosphorus trichloride-DMF adducts can be reacted with cellulose to obtain FR fabrics.

Developed FR based on THPOH and guanazole.

The less highly substituted phosphorus amides are more readily bound to cellulose.

Developed method for the quantitative analysis of Thpc solutions.

Developed method for stabilizing THPOH-NH_3 solutions with metals.

Flame retardant formulations for wool were developed.

Demonstrated that phosphinidynetrimethanol triacetate could be applied to cellulosic materials.

Delineated the effect of sample holder construction on OI values.

Wet method for determining the oxidized state of phosphorus developed.

Defined the flammability properties of mixture of Thpc treated cotton and synthetic fibers.

Prepared soluble methylol phosphine adducts containing halogen atoms attached to carbon atoms.

Back coating formulations for bed ticking developed.

PATENTS AND LICENSES CONCERNING FLAME RETARDANT RESEARCH (PRIOR TO 1964)

PATENT #	TITLE	DATE ISSUED
3,017,237	"Cellulose Derivative and Method of Preparing Same"	1/16/62
2,993,888	"Process for the Reaction of Isocyanates with Cellulose in the Presence of Organic Phosphites"	7/25/61
2,980,491	"Textile Fibers Comprising Perfluoroalkanoyl Ethers of Cellulose and Process of Making the Same"	4/18/61
2,979,374	"Fibrous Textile Cellulosic Phosphonomethyl Ethers and Process of Preparation"	4/11/61
2,939,849	"N-Epoxypropyl Phosphoramides and Method of Producing the Same"	6/ 7/60
2,933,367	"Flame-Resistant Textiles by Chemical Modification of Cotton"	4/19/60
2,917,492	"Reaction Products of 1-Aziridinyl Compounds with Compounds Containing Active Methylene Groups"	12/15/59
2,915,480	"Aziridine-Carboxylic Acid Polymers"	12/ 1/59
2,912,412	"Aziridine-Phenolic Polymers"	11/10/59
2,911,325	"Flame Resistant Organic Textiles and Method of Production"	11/ 3/59
2,906,592	"Flame and Crease Resistant Textiles from Aziridinyl Carboxyalkylcellulose"	9/29/59
2,901,444	"Polymers Made from 1-Aziridinyl Phosphine Oxides and Sulfides and Flame Resistant Organic Textiles"	8/25/59

PATENT #	TITLE	DATE ISSUED
2,892,803	"Composition Comprising Nitrilo Methylol-Phosphorus Polymer and Organic Textiles Flame-Proofed Therewith"	6/30/59
2,891,877	"Flame Resistant Organic Textiles and Method of Production:	6/23/59
2,889,289	"Phosphorus Containing Aziridinyl-Amine Polymers and Flame Resistant Organic Textiles"	6/ 2/59
2,913,436	"Phosphorus-Containing Polyesters and Method for Their Production"	11/17/59
2,886,539	"Aziridine-Methylolphosphorus Polymers and Flame Resistant Organic Textiles"	5/12/59
2,886,538	"Phosphorus Containing Aziridinyl-Alcohol Polymers and Flame Resistant Organic Textiles"	5/12/59
2,870,042	"Flame Resistant Organic Textiles and Method of Production"	1/20/59
2,861,901	"Bromine Containing Nitrilo Methylol-Phosphorus Polymers"	11/25/58
2,859,134	"Flame Resistant Organic Textiles and Method of Production:	11/ 4/58
2,830,964	"Process of Producing Ethylene Oxide Methylol Phosphorus Polymers, Products Obtained and Aqueous Compositions Thereof"	4/15/58

PATENT #	TITLE	DATE ISSUED
2,825,718	"Alkenyl Phosphonitrilic Ester - Polyhalohydrocarbon Adducts"	3/4/58
2,814,573	"Organic Polymeric Compositions Containing Nitrilo-Methylol-Phosphorus Polymers and Bromine Compounds"	11/26/57
2,812,311	"Water Dispersible Solid Nitrilo-Methylol-Phosphorus Polymers"	11/5/57
2,810,701	"Aqueous Emulsion-Suspension Textile Treating Compositions and Processes of Treating Textiles with Same"	10/22/57
2,809,941	"Producing Phosphorus Containing Amino Resins and Flameproofing Organic Textiles"	10/15/57
2,795,569	"Ethyleneimine Methylol-Phosphorus Polymers and Process of Preparation"	6/11/57
2,778,747	"Process of Preparing Triallyl Phosphate-Polyhalomethane Polymers and Process of Flameproofing Textiles Therewith"	1/22/57

PATENT #	TITLE	DATE ISSUED
2,772,188	"Ammonia Insolubilized Methylol-Phosphorus Polymers and Cellulosic Materials Impregnated Therewith"	11/27/56
2,846,413	"Phenolic Methylol-Phosphorus Polymers"	8/5/58
2,768,997	"Phosphorus-Containing Polypeptides"	10/30/56
2,743,299	"Production of Tetrakis(hydroxymethyl)phosphonium Chloride"	4/24/56
2,743,232	"Fibrous 2-Phosphatoethyl Ethers of Cellulose and Process of Making the Same"	4/24/56
2,711,998	"Aqueous Haloalkyl Phosphate-Amino Resin Flameproofing Composition"	6/28/55
2,695,833	"Process for Making Flameproofed Dyed Aminized Cotton Fabrics"	11/30/54
2,686,769	"Flameproofing Aqueous Suspensions of Halomethylated Phosphates"	8/17/54
2,686,768	"Suspensions of Polymeric Flameproofing Compositions Containing Phosphate and Halomethyl Groups"	8/17/54
2,681,295	"Process for Flameproofing Textiles with Poly-Phosphonitrilic Ester"	6/15/54
2,668,096	"Flameproofed Fibers Aminoalkylated Cellulose Derivatives"	2/ 2/54

PATENT #	TITLE	DATE ISSUED
2,462,803	"Flameproofing Compositions"	2/22/49
2,428,843	"Flame-Resistant Cellulosic Material and Process for Producing Same"	10/14/47

PATENTS AND LICENSES CONCERNING FLAME RETARDANT RESEARCH (1964 THROUGH 1974)

PATENT #	TITLE	DATE ISSUED
3,146,228	"N,N'-Ethylene Bis[P,P-Bis(1-Aziridinyl)-N-Methyl Phosphinic Amide] and Homopolymer Thereof"	8/25/64
3,181,225	"Process of Resin Treating a Cotton Batting"	5/4/65
3,197,269	"Reactive Dyestuffs for Cellulosic Textiles and Process of Application"	7/27/65
3,205,034	"Process for Treating Cotton Textiles with N-N'-Ethylene Bis[P,P-Bis(Aziridinyl)-N-Methyl Phosphinic Amide]"	9/7/65
3,250,811	"Methylol Derivatives of Tris(2-Carbamoylethyl)Phosphine Oxide"	5/10/66

PATENT #	TITLE	DATE ISSUED
3,268,292	"Process of Treating Cellulosic Textiles with N-Methylol Derivatives of Tris(2-Carbamoylethyl)Phosphine Oxide and Products Thereof"	8/23/66
3,268,360	"Composition Comprising Diisocyanate Methylol-Phosphorus Polymer and Organic Textile Flameproofed Therewith"	8/23/66
3,270,052	"Tris(2-Carbamoylethyl)Phosphine and Its Methylol Derivates"	8/30/66
3,276,897	"Flame Resistant Cellulosic Materials"	10/4/66
3,276,838	"Process of Treating Cellulosic Textiles with Methylol Derivatives of Tris(2-Carbamoylethyl)Phosphine and Products Thereof"	10/4/66
3,278,497	"Reaction Products of (1) Aziridinyl Compounds, (2) Methylol Phosphorus Compounds and (3) Sulfur Compounds"	10/11/66
3,318,659	"Process of Treating Cellulose Textiles with Polyvinyl Chloride Polymers, a Polysiloxane and Zirconium Acetate and Optionally with Flame Resistant and Rot Resistant Agents"	5/9/67
3,350,164	"Acid Catalyzed Modification of Cellulosic Materials with Methylolated, Halo-Cyanoacetamides"	10/31/67
3,403,044	"Process for Flameproofing Cellulosic Material"	9/24/68
3,403,174	"Methylol Derivatives of Halo-Cyanoacetamides and Their Application to Cellulosic Materials"	9/24/68
3,404,022	"Process for Flameproofing Cellulosic Material"	10/1/68
3,414,367	"Process for Making N-Substituted Aminoethylsulfonylethyl Ethers of Cellulose"	12/3/68

PATENT #	TITLE	DATE ISSUED
3,459,589	"Process for Reducing the Flammability and Increasing the Weather-Resistance of Fibrous Organic Materials	8/5/69
3,480,381	"Cellulose-Halomethyl Methyl Sulfide Reaction Process and Product"	11/25/69
3,484,184	"Haloalkyl Phosphinic Acids and Their Application to Cotton"	12/16/69
3,488,140	"Phosphorylation of Cotton with Inorganic Phosphates"	1/6/70
3,494,720	"Bis(Sulfatomethyl)Phosphinic Acid"	2/10/70
3,535,073	"Crosslinking Cotton with Haloalkyl Phosphine Oxides"	10/20/70
3,563,689	"Process Useful to Produce a Fabric that Exhibits Improved Fire Retardant Properties Utilizing Halogenated Oxirane and Thirane Reactants"	2/16/71
3,563,691	"Process for Producing a DEAE Cellulosic Fabric Which Incorporates Reversible Cross-Links"	2/16/71
3,563,692	"Diethylaminoethylated Cellulose Weak Base Anion Exchanger Containing Sulfhydryl Groups"	2/16/71
3,574,719	"Haloalkyl Phosphinic Acids and Their Application to Cotton"	4/13/71
3,607,944	"Sone Bis(Halomethyl)-Phosphorylme Thyltriphenyl-phosphonium Halides and a Stable Phosphine Methylene"	9/21/71
3,607,356	"Imparting Flame Resistance to Fibrous Textiles from an Alkaline Medium"	9/21/71

PATENT #	TITLE	DATE ISSUED
3,617,346	"Aziridine Adducts of α,β-Unsaturated Nitriles and Polymers Thereof"	11/2/71
3,625,738	"Process for Stabilizing Organophosphorus Solutions and Imparting Rot and Flame Resistance to Organic Textile Materials"	12/7/71
3,629,052	"Process for Imparting Flame-Retardancy to Resin-Treated Cotton Batting"	12/21/71
3,636,088	"Haloalkyl Phosphinic Acids and Their Application to Cotton"	1/18/72
3,639,144	"Organo-Phosphorus Compounds Containing Perfluoroalkyl Radicals and Their Application to Cellulosic Textiles"	2/1/72
3,645,869	"Preparation of a Fibrous Thermoplastic Copolymer of Cotton and Styrene by Radiation Treatment"	2/29/72
3,654,274	"Phosphorus-Containing Triazines"	4/4/72
3,694,256	"Process for Rendering Cellulosic Textiles Flame Retardant"	9/26/72
3,697,316	"Fire-Resistant Organic Products and Method for Production"	10/10/72
3,698,854	"Process for Producing Flame Resistant Organic Textiles"	10/17/72
3,702,232	"Tris(2-Chloroethyl)Phosphoramide Used as a Crosslinking Agent for Cellulosic Compositions"	11/7/72
3,719,448	"Organo-Phosphorus Compounds Containing Perfluoroalkyl Radicals and Their Application to Cellulosic Textiles"	3/6/73

PATENT #	TITLE	DATE ISSUED
3,723,057	"Process for Stabilizing Organophosphorus Solutions and Imparting Rot and Flame Resistance to Organic Textile Materials"	3/27/73
3,725,001	"Phosphinidynetrimethanol Triacetate and Its Application to Cellulosic Materials"	4/3/73
3,732,073	"N,N-Diethylaziridinium Chloride as a Coreactant Catalyst for Reactions of N-Methylol Reagents with Cellulose"	5/8/73
3,734,684	"Flame Retardant Phosphorus Containing Fibrous Products and Method for Production"	5/22/73
3,745,191	"Flame-Resistant Organic Textiles Through Treatment with Halogen Containing Soluble Methylol Phosphine Adducts"	7/10/73
3,763,282	"Perfluoroalkyl Phosphonates"	10/2/73
3,787,360	"Phosphorus Containing Aromatic Polymers and Process for Producing Flame-Resistant Textiles"	1/22/74
3,790,639	"Process for Producing a Water-Soluble Methylol Phosphine-Phenol Adduct"	2/5/74
3,796,596	"Finishing Process Incorporating Improved Catalyst Systems to Produce Durable Flameproofed Cellulosic Textile Products with an Excellent Hand"	3/12/74
3,819,580	"Flame Resistant Organic Textiles Through Treatment with Halogen Containing Soluble Methylol Phosphine Adducts"	6/25/74

PATENT #	TITLE	DATE ISSUED
3,833,661	"Novel Process for the Preparation of Tris(Hydroxymethyl) Phosphine and Tris(Hydroxymethyl)Phosphine Oxide"	9/3/74
3,844,824	"Process of Treating Fibrous Materials with the Reaction Product of Methylolphosphine Adducts and Nitrogenous Compounds"	10/29/74
3,845,107	"Phosphinidynetrimethanol Triacetate"	10/29/74

PATENTS APPLIED FOR CONCERNING FLAME RETARDANT RESEARCH (June, 1970, to March, 1975)*

TITLE

"Tris(2-Chloroethyl)Phosphoramide-A Crosslinking Agent for Cellulosic Compositions"

"Organo-Phosphorus Compounds Containing Perfluoroalkyl Radicals and Their Application to Cellulosic Textiles"

"Alpha-Bis(Phosphone)Dicarboxylic Acid Derivatives"

"Flameproofing of Cotton Cellulose with Hexamethyl Phosphorus Triamide"

"Process for Producing Fire Resistant Organic Textile Materials"

"3,7 Dicyano-3,5,7-Triaza-1-Phosphabicyclo (3.3.1) Nonane and Derivatives"

"Quaternary Arylaminoalkyl Phosphonium Salts and Process for the Preparation Thereof"

"Monophosphorus Analog of Hexamethylenetetramine and Derivatives"

"Flame Retardant-Smolder Resistant Multiple Density Cotton Batting Products"

"Flame Retardation of Textiles by Crosslinking Halo Phosphorus Compounds with Polyethylenimine"

"Flame-Retardant Textiles by Reaction of Cellulose with the Adducts of Phosphorus Trichloride and N,N-Dimethylformamide"

"Method of Application of THPOH-NH_3 Fire Retardant Finish to Textiles"

"Phosphaadamantanes: Synthesis of 2-Thia-1,3,5-Triaza-7-Phosphaadamantane 2,2-Dioxide and Derivatives"

"Flame Retardant Textiles by Use of Nitrogenous Type Resin and Antimony Oxide"

TITLE	DATE APPLIED FOR
"Phosphorus, Nitrogen, Bromin Containing Polymers and Process for Producing Flame Retardant Textiles"	8/22/74
"Flameproofing Resins for Organic Textiles from Adduct Polymers"	8/22/72
"Phosphorus and Nitrogen Containing Resins for Flameproofing Organic Textiles"	8/22/74
"Treatment of Organic Textiles with Adduct Polymers and Phenols"	8/22/74
"Flame Resistant Organic Textiles Through Treatment with Phenols and Adduct Polymers"	8/22/74
"Flame-Resistant Textiles Through Finishing Treatments with Vinyl Monomer Systems"	8/28/74
"Ultraviolet-Initiated Preparation of N,N-Dibutyl-9(10)-Dibutylphosphonooctadecanamide"	9/26/74
"Quaternary Arylaminoalkyl Phosphonium Salts and Process for the Preparation Thereof"	12/5/74
"Ditto"	12/5/74
"A Vapor Phase Process to Impart Smolder Resistance to Cotton Batting and Other Cellulosic Materials"	Forwarded to the U. S. Patent and Trademark Office 3/5/75

PROGRESS TOWARD OBJECTIVES

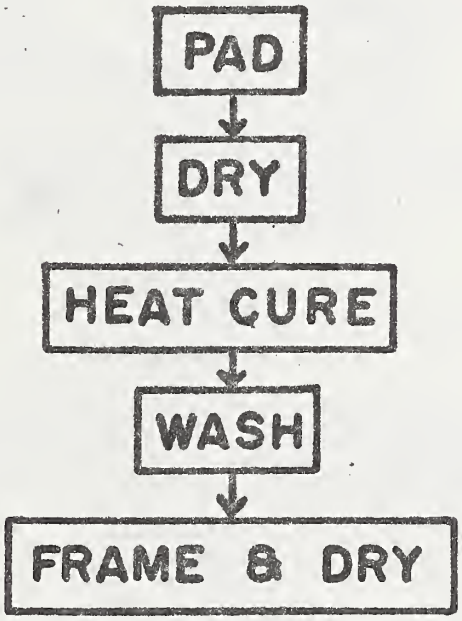
Appendix-F

Commercial Products

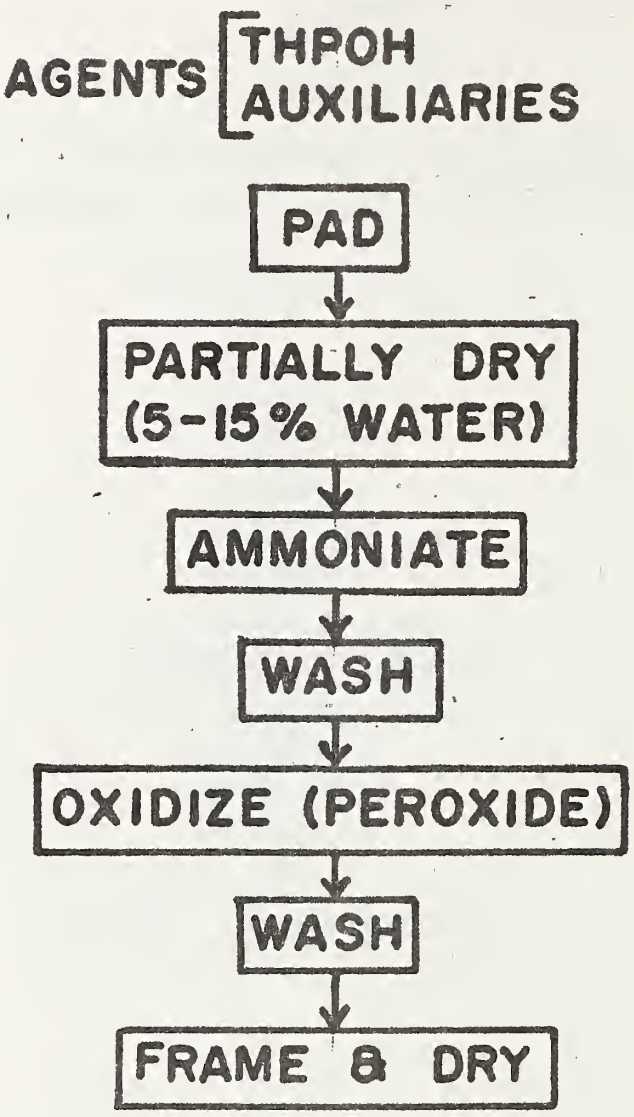
Thpc-AMIDE F-R PROCESS
(Typical of the three)

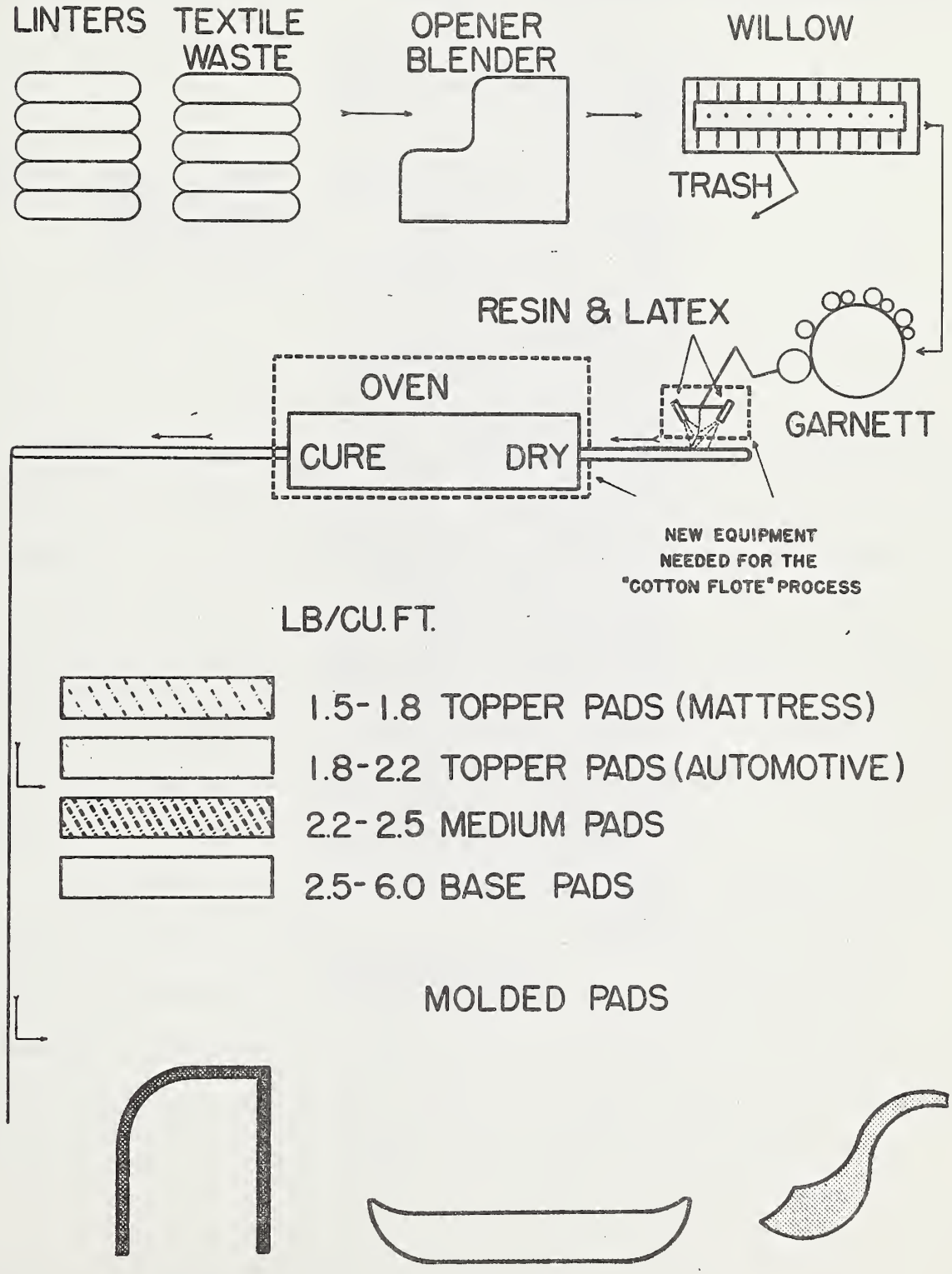
AGENTS

- Thpc
- Urea
- Methylolmelamine
- Sodium Hydroxide
- Auxiliaries



THPOH / AMMONIA F-R PROCESS




LINTERS
TEXTILE WASTE
OPENER BLENDER
WILLOW
TRASH
RESIN & LATEX
OVEN
CURE
DRY
GARNETT
NEW EQUIPMENT NEEDED FOR THE "COTTON FLOTE" PROCESS
LB/CU.FT.
1.5-1.8 TOPPER PADS (MATTRESS)
1.8-2.2 TOPPER PADS (AUTOMOTIVE)
2.2-2.5 MEDIUM PADS
2.5-6.0 BASE PADS
MOLDED PADS

Market Grows In "Fire Stop" Cotton

Avondale Mills has joined the growing ranks of fabric finishers whose flame retardant cotton cloth for children's sleepwear qualifies for the "Fire Stop" license from U. S. cotton growers, it was announced this week in New York.

"Fire Stop" is a registered trademark for fabrics containing at least 65 per cent cotton that have been treated to meet government and industry flammability standards.

The "Fire Stop" trademark is owned by Cotton Incorporated, the fiber company representing U. S. cotton growers.

Avondale Mills will produce flame retardant flannels containing 65 per cent cotton and 35 per cent polyester. The fabric will be treated for flame retardance with the THPOH/Ammonia process. developed by textile chemists at the Southern Regional Research Center of the U. S. Department of Agriculture at New Orleans.

"We welcome Avondale to the lineup of mills qualifying for the 'Fire Stop' standard of excellence in fire retardant clothing," said J. Nicholas Hahn, vice president for sales and marketing at Cotton Incorporated.

Avondale Vice President A. C. Svensson said his company's "Fire Stop" flannels will appear in children's sleepwear next fall in leading chain stores and in retail outlets featuring major independent brands.

Avondale, one of America's top 20 textile firms, also represents yarn spinners and griege goods mills and sells finished fabrics. In its "Fire Stop" program, Avondale styles, merchandises and sells flannels made by Wade Manufacturing Company.

Cotton Incorporated and Avondale plan a joint advertising and promotional campaign to boost consumer awareness of the new "Fire Stop" products.

THE COTTON DIGEST
March 8, 1975

Hooker
)KER CHEMICAL CORPORATION
3ARA FALLS, NEW YORK 14302
)BSIDIARY OF OCCIDENTAL PETROLEUM CORPORATION

News Release

69-20

FOR RELEASE: IMMEDIATE

CONTACT: JAMES M. GREEN
Regional Manager
Public Relations
(716) 773-2345

NIAGARA FALLS, N.Y., July 3, 1969---The development of a new process for imparting a fire-retardant finish to lightweight cotton and rayon fabrics was announced today by Hooker Chemical Corporation. Successful commercial-scale trial runs of the new process have been conducted under the supervision of Hooker's textile research chemists at finishing mills licensed by the firm to utilize Hooker's proprietary THPC® resin technology. The new flame retardant process provides marked improvements in the physical properties of lightweight fabrics in two highly significant areas: Strength retention and "hand" or feel.

The process, as brought to levels of commercial acceptance and performance by Hooker's Industrial Chemicals Division textile laboratory group, is a outgrowth of technology developed by cotton finishing chemists associated with the U. S. Department of Agriculture's Southern Utilization Laboratories at New Orleans, La. Hooker researchers describe the process, which uses THPOH*, as a second generation member of the company's THPC® based resin finish systems.

-more-

*tetrakis (hydroxymethyl)-phosphonium hydroxide (THPOH)

the successor to foam

Cotton·Flote is a totally new concept in cushioning comfort . . . and millions of car buyers will benefit! Chemical research encouraged by the automotive industry and carried out by the U. S. Department of Agriculture and the entire cotton industry has produced this advanced new cushioning. Cotton·Flote has superior resilience, lasting flexibility and the natural cooling qualities of cotton. It's one of the great new improvements in comfort in the great new 1966 automobiles.

NATIONAL COTTON COUNCIL AND NATIONAL COTTON BATTING INSTITUTE, MEMPHIS, TENNESSEE

PROGRESS TOWARD OBJECTIVES

Appendix-F

Technical Assistance

TECHNICAL CONSULTATIONS BY LETTERS AND TELEPHONE CONSERVATIONS

	LETTERS NUMBER	TELEPHONES
1967	38	10
1968	113	9
1969	106	66
1970	130	122
1971	43	121
1972	133	185
1973	90	195
TOTAL	653	708

DISTRIBUTION OF TECHNICAL CONSULTATIONS BY TELEPHONE AND LETTERS, FIRE RETARDANT FABRIC AREA, 1967-1973

STATE OR COUNTRY	TELEPHONE		LETTERS	
	NUMBER OF CALLS	PERCENT OF TOTAL[1]	NUMBER	PERCENT OF TOTAL
ALABAMA	11	1.6	9	1.4
ARKANSAS	1	0.1	--	---
CALIFORNIA	14	2.0	19	2.9
COLORADO	2	0.3	2	0.3
CONNECTICUT	5	0.7	5	0.8
DELAWARE	4	0.6	14	2.1
FLORIDA	3	0.4	2	0.3
GEORGIA	41	5.8	23	3.5
HAWAII	--	---	2	0.3
ILLINOIS	25	3.5	16	2.5
INDIANA	3	0.4	4	0.6
IOWA	--	---	1	0.2
KANSAS	3	0.4	3	0.5
KENTUCKY	1	0.1	2	0.3
LOUISIANA	26	3.7	24	3.7
MASSACHUSETTS	20	2.8	19	2.9
MARYLAND	17	2.4	14	2.1
MICHIGAN	9	1.3	17	2.6
MONTANA	2	0.3	--	---
MINNESOTA	5	0.7	10	1.5
MISSISSIPPI	6	0.8	5	0.8
MISSOURI	8	1.1	8	1.2
NORTH CAROLINA	85	12.0	65	10.0
NORTH DAKOTA	--	---	1	0.2
NEW JERSEY	67	9.5	47	7.2
NEW YORK	103	14.5	70	10.7
OHIO	25	3.5	12	1.8
OKLAHOMA	--	---	4	0.6
OREGON	--	---	1	0.2
PENNSYLVANIA	12	1.7	18	2.8
RHODE ISLAND	2	0.3	8	1.2
SOUTH CAROLINA	83	11.7	60	9.2
TENNESSEE	44	6.2	25	3.8
TEXAS	28	4.0	20	3.1
UTAH	--	---	1	0.2
VIRGINIA	4	0.6	10	1.5
WASHINGTON	--	---	3	0.5
WEST VIRGINIA	3	0.4	8	1.2
WASHINGTON D.C.	38	5.4	34	5.2
WISCONSIN	5	0.7	6	0.9

DISTRIBUTION OF TECHNICAL CONSULTATIONS BY TELEPHONE AND LETTERS, FIRE RETARDANT FABRIC AREA, 1967-1973 (CONTINUED)

STATE OR COUNTRY	TELEPHONE		LETTERS	
	NUMBER OF CALLS	PERCENT OF TOTAL 1/	NUMBER	PERCENT OF TOTAL 1/
AUSTRALIA	--	---	1	0.2
CANADA	3	0.4	6	0.9
ENGLAND	--	---	13	2.0
GERMANY	--	---	9	1.4
HOLLAND	--	---	2	0.3
HONDURAS	--	---	1	0.2
INDIA	--	---	5	0.8
IRELAND	--	---	2	0.3
ITALY	--	---	2	0.3
JAPAN	--	---	4	0.6
MEXICO	--	---	1	0.2
NORWAY	--	---	1	0.2
PHILLIPINES	--	---	1	0.2
SWITZERLAND	--	---	4	0.6
SWEDEN	--	---	7	1.1
TAIWAN	--	---	1	0.2
THAILAND	--	---	1	0.2
TOTAL	708	100.0	653	100.0

1/ May not add to total due to rounding.

CLASSIFICATION OF TELEPHONE TECHNICAL CONSULTATIONS BY NEW AND PRIOR SUBJECT MATERIALS

	TOTAL NUMBER OF TELEPHONE CONSULTATIONS	CONSULTATIONS CLASSED BY: NEW SUBJECT MATERIAL	CONSULTATIONS CLASSED BY: PRIOR SUBJECT MATERIAL
1967	10	10	--
1968	9	9	--
1969	66	49	17
1970	122	68	54
1971	121	81	40
1972	185	69	116
1973	195	29	166
TOTAL	708	315	390

TECHNICAL CONSULTATIONS CLASSED BY SUBJECT, RETARDANT, AND RETARDANT SYSTEMS
1964-1973

FLAME RETARDANTS OR RETARDANCE

Markets and potential
Test procedures
Processing
Equipment
Current research
Use on coveralls
Use on cotton fabrics
Processes
Test methods
Chemical prices
Formulations, general
Publicity
Decomposition products
Toxicity
Publication
Seminars
Soil resistance
Organo phosphorous chemistry
Cyannic acid derivatives
Ammonium phosphate uses
Fabric samples
Use on cotton chenille
Use as carpet backing
Use of antimony
Autoclaving cotton textiles
Research proposals
Use on jute backing
Use on drapery
Formulations for sleepwear
PHS study results
Use on cotton broadcloth
Ion exchange properties
Proposed QM specifications
Treated sateen samples
Availability of chemicals
Use of methylgycouril
Laundry pilot plant run
Halogenation of cellulose
Medical studies
Decomposition on rugs
P-N-Cl_2 derivatives
Dielectric heating
Detergent effects
Use on mop yarns
Cleaning agent effects
Cellulose combustion
CI values
Physical effect on fabrics
Use on yarns
Regulations
Pilot plant runs
P containing triazines
Evaluations
Patents
Use on cotton batting
Application costs
Use on cotton knits
Use on chenille robes
Fabric production
Antimony oxides for tarpaulins
SVF test
Effects of line drying
Burn data
Use on personnel protection uniforms
Cost/benefits
Use on rugs
Use on aerosol equipment
Availability for uniform fabrics
Plant visit
NMR spectroscopy
Heat stability
Light stability
Laundry durability
Weathering effects
Phosphorus determinations
Use on knit fabrics
Use on sewing threads
Use of bromine compounds
Use on fire fighters uniforms
Dermatological studies
Pilot plant equipment
Chlorine bleaching effect
Burn prevention
Hard water effects
Contract agreements
Labeling
Speaker availability
Carbonate detergent effects
Round robin test
Water repellency
Use on cotton/polyester blends
Use on canvas duck
Zirconium salt complexes
Availability of nondurable FR
Bromoform adducts
Effects of relative humidity
Polyvinylbromine for blends
Solvent finishes

TECHNICAL CONSULTATIONS CLASSED BY SUBJECT, RETARDANT, AND RETARDANT SYSTEMS
1964-1973 (CONTINUED)

Use on mattresses
Ammonia cure chambers
Use on recreational tentage
Use on industrial uniforms
Moisture regain
Tentage standards
Use on manuscripts
Volatile phosphorus compounds
Effect of lime dispersed soaps
Halocyanacetamides
Phosphoroxy trimile
Phosphorous analysis
FR status
Moisture effect
Environmental effect
Children's sleepwear status
Oxygen effect on cellulose char
PvBr emulsion stabilization
Elimination of afterglow
Chemical reactions
Methylolated dicyandiamite

THPOH-NH_3

Fabric samples
Application on cotton fabrics
Burning rates
Use on napped fabrics
Use on cotton/polyester blends
Use on sateen
Light fastness
Use on knit fabrics
Use on bed pads
Use on blankets
Use on tuffed cotton robes
Formaldehyde release
Formulations
Cross section preparation
Post dyeing
Processing variables
Chemistry
Sulfite modifications
Heat buildup in curing
Use on sewing threads
Application equipment
Fabric strength
Use on wool fabrics
Test results
Laboratory equipment
Use on blankets
Pilot plant runs
Commercialization
Use on flannel
Use on textile liners
Use on knitted sleepwear
Use on medium weight fabrics
Use on ramie
Patents
Use on bedspreads
Equipment
Oxidation
Use of liquid ammonia
Use on flannel sleepwear
Use on terry cloth
Carbonate washing effects
In-plant process problems
Current improvements
Dermatological effects
Peroxide oxidation
Publications

THPOH-AMIDE

Plant trials
Use on bedspreads
Use on cotton fabrics
Catalyst use
Rug samples
Use on tubular knits
Cloth samples
Publications

TECHNICAL CONSULTATIONS CLASSED BY SUBJECT, RETARDANT, AND RETARDANT SYSTEMS
1964-1973 (CONTINUED)

THPC

Processes
Toxicity
Use on plane seat headrests
Odor
Analysis
Commercial availability
Research status
Use on lambskins
Derivatives
Use on heavy and lightweight fabrics
Application methods
Use on work clothing
Pilot plant runs
Environmental effects
Chemical reactions

APO

Textile uses
Processes

THPC-THPO

Textile uses
Processes

THPC-CYANAMIDE

Textile uses
Use on jute rug backing
Use on rugs
Available processes
Plant runs
Use on cotton fabrics
Use on blankets

THPOH

Textile use
Toxicity
Use on upholstery
Commercial plant run
Catalyst chemistry
Publications

THPOH-TMM-UREA

Use on sheeting
Publications

THPOH-MM-UREA

Use on paper
Pilot plant runs
Ultra violet stability
Publications

THPC-CYANAMIDE-H_3PO_4

Textile uses
Publication

TECHNICAL CONSULTATIONS CLASSED BY SUBJECT, RETARDANT, AND RETARDANT SYSTEMS
1964-1973 (CONTINUED)

OTHERS

THP syntheses
THPC-amide-$PvBr_2$ use on blends
THPC-urea-glycolurea process
THPC-cyamide-trimethylolactylene diurea process
THPOH-Cu-NH_3 process
THPC-urea PvBr process variables
THPC-urea-TMM U processes
THPC-urea-disodium acid phosphate
Alkyl (amino-s-triazinyl phosphonates
Tris(carbamoylethyl)phosphine oxide
Dapt process

ATTENDANCE PROFILE: AT THE COTTON UTILIZATION CONFERENCES, SRRC, 1964-1973

NUMBER

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	TOTAL
Industry	73	126	195	182	146	163	131	99	111	90	1316
Industry assoc.	6	6	7	5	7	3	6	5	7	7	59
Govt. agencies	3	16	14	8	8	10	24	10	16	7	116
Universities	10	25	23	18	21	23	17	23	16	15	191
Others	14	53	30	19	30	21	29	24	18	6	244
Total	106	226	269	232	212	220	207	161	168	125	1926

PERCENT

Industry	68.9	55.8	72.5	78.4	68.9	74.1	63.3	61.5	66.1	72.0	68.3
Industry assoc.	5.7	2.7	2.6	2.2	3.3	1.4	2.9	3.1	4.2	5.6	3.1
Govt. agencies	2.8	7.0	5.2	3.4	3.8	4.5	11.6	6.2	9.5	5.6	6.0
Universities	9.4	11.0	8.6	7.8	9.9	10.5	8.2	14.3	9.5	12.0	9.9
Others	13.2	23.5	11.1	8.2	14.1	9.5	14.0	14.9	10.7	4.8	12.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTE: Does not include attendance of SRRC personnel.

ATTENDANCE PROFILE: COTTONSEED PROCESSING CLINIC, 1964-1973

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	TOTAL
	-NUMBER-										
INDUSTRY	60	85	71	78	65	66	71	62	42	88	688
INDUSTRY ASSOC.	5	5	1	4	3	5	5	4	4	2	38
GOVT. AGENCIES	6	10	3	7	10	10	13	18	8	3	88
UNIVERSITIES	1	3	4	2	2	4	5	13	5	5	44
OTHERS	7	11	5	7	13	14	14	13	11	6	101
TOTAL	79	114	84	98	93	99	108	110	70	104	959
	-PERCENT-										
INDUSTRY	75.9	74.6	84.5	79.7	69.9	66.7	65.8	56.4	60.0	84.6	71.7
INDUSTRY ASSOC.	6.3	4.4	1.2	4.1	3.2	5.1	4.6	3.6	5.7	1.9	4.0
GOVT. AGENCIES	7.6	8.8	3.6	7.1	10.8	10.1	12.0	16.4	11.4	2.9	9.2
UNIVERSITIES	1.3	2.6	4.8	2.0	2.2	4.0	4.6	11.8	7.1	4.8	4.6
OTHERS	8.9	9.6	5.9	7.1	13.9	14.1	13.0	11.8	15.8	5.8	10.5
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

NOTE: DOES NOT INCLUDE ATTENDANCE OF SRRC PERSONNEL; PERCENTAGES ROUNDED.

PROFILE OF ATTENDANCE AT THE 1973 COTTON UTILIZATION CONFERENCE

REPRESENTING	NUMBER
INDUSTRY	90
INDUSTRY ASSOCIATIONS	7
GOVERNMENT AGENCIES	7
UNIVERSITIES	15
OTHERS	6
TOTAL	125

GEOGRAPHIC PROFILE OF ATTENDANCE AT THE 1973 COTTON UTILIZATION CONFERENCE

STATE OR NATION	NUMBER
ALABAMA	6
CONNECTICUT	1
DELAWARE	2
FLORIDA	1
GEORGIA	13
INDIANA	2
ILLINOIS	5
LOUISIANA	7
MASSACHUSETTS	4
MARYLAND	3
MICHIGAN	1
MISSISSIPPI	2
MISSOURI	1
NEW YORK	11
NORTH CAROLINA	15
NEW JERSEY	8
OHIO	2
PENNSYLVANIA	4
RHODE ISLAND	2
SOUTH CAROLINA	15
TENNESSEE	12
TEXAS	3
VIRGINIA	2
WASHINGTON, D.C.	2
ENGLAND	1
TOTAL	125

PILOT PLANT RUNS AND SAMPLE DISTRIBUTIONS, NON-SRRC PERSONNEL, BY TYPE OF FIRE RETARDANT, 1963-1974

TREATMENT	PILOT PLANT RUNS	SAMPLE DISTRIBUTION
APO	1	1
APO-THPC	27	21
APO-THPC-NH_3	--	1
BORIC ACID PYROSAN B	--	1
THPOH	9	9
THPOH-AMIDE	20	8
THPOH-UREA-NA_2HPO_4	1	--
THPOH-NH_3	70	50
THPOH-MM-UREA	--	2
THPOH-UREA-TMM	1	3
THPOH-NH_3-COPPER NITRATE	--	1
THPOH-CU-NH_3	1	--
THPC	--	6
THPC-MM	--	2
THPC-UREA-NH_3	--	1
THPC-UREA	4	1
THPC-UREA-NH_2-HPO_4	6	1
THPC-AMIDE	5	10
THPC-CYANAMIDE	1	14
THPC-CYANAMIDE-NA_2HPO_4	7	--
THPC-UREA-TMMGU	1	2

PILOT PLANT RUNS AND SAMPLE DISTRIBUTIONS, NON-SRRC PERSONNEL, BY TYPE OF FIRE RETARDANT, 1963-1974 (CONTINUED)

TREATMENT	PILOT PLANT RUNS	SAMPLE DISTRIBUTION
THPC-UREA-PVBR	7	2
THPC-CYANAMIDE-H_3PO_4	1	2
THPC-UREA-TMMGU-NA_2HPO_4	1	-
THPC-UREA-PVBR-TMMGU	1	-
UREA PHOSPHATE + FC 210	-	4
FR GENERAL	7	38
TOTAL	179	180

PILOT PLANT RUNS AND SAMPLE DISTRIBUTIONS, NON-SRRC PERSONNEL, FABRIC TREATMENT PROGRAM, 1963-1974

	PILOT PLANT TREATMENTS FOR NON-SRRC PERSONNEL	SAMPLES DISTRIBUTED TO NON-SRRC PERSONNEL
1963	12	--
1964	--	1
1965	1	2
1966	5	6
1967	14	19
1968	22	11
1969	6	22
1970	44	31
1971	18	37
1972	18	35
1973	22	8
1974	17	8
TOTAL	179	180

IN-PLANT COMMERCIAL TRIALS WITH SRRC FLAME RETARDANTS

	NUMBER
1963	9
1964	5
1965	3
1966	3
1967	10
1968	11
1969	11
1970	11
1971	15
1972	2
1973	16
1963-73	96

TOURS OF SRRC FACILITIES

YEAR	NUMBER	ATTENDEES
1965	94	1465
1966	78	1051
1967	77	1212
1968	76	1199
1969	71	1186
1970	90	1239
1971	92	1098
1972	79	1184
1973	66	1002
TOTAL	723	10636

SUMMARY OF THE COST AND BENEFITS FROM THE FIRE RETARDANT PROGRAM, SRRC, 1964-1973

Appendix-G

VALUE OF TECHNICAL PRESENTATIONS AT THE ANNUAL COTTON UTILIZATION CONFERENCES
SRRC, 1964-1973

	PER DIEM DOLLARS[1/]	MILEAGE DOLLARS[1/]	SALARY DOLLARS[1/]	TOTAL DOLLARS	VALUE ATTRIBUTABLE TO FIRE RETARDANT PROGRAM	
					PERCENT[2/]	DOLLARS
1964	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1965	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1966	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1967	17,400.00	64,209.30	58,617.11	140,226.41	11.0	15,424.91
1968	15,900.00	60,084.30	53.563.91	129,548.21	4.3	5,570.57
1969	16,500.00	61,046.90	55,585.19	133,132.09	12.5	16,641.51
1970	15,525.00	57,516.90	52,300.61	125,342.51	20.8	26,071.24
1971	12,075.00	40,506.30	40,678.25	93,259.55	28.0	26,112.67
1972	12,600.00	44,552.70	42,446.87	99,599.57	47.8	47,608.59
1973	9,375.00	31,538.40	21,041.82	61,955.22	40.0	24,782.09
1967-73	99,375.00	359,454.00	500,263.02	959,092.02	----	162,211.58

1/ Per diem at $25, mileage for round trips at 15 cents per mile, and salary was based on $84.22 per day. See Appendix Table G-2 for attendance, mileage and number of meeting days.

2/ Flame retardant presentations as a percent of total presentations.

FACTORS FOR COMPUTING THE VALUE OF TECHNICAL PRESENTATIONS AT THE COTTON UTILIZATION CONFERENCES, SRRC, 1964-1973

	ATTENDANCE	ONE WAY MILEAGE	MEETING DAYS	PERCENT OF PROGRAM ON FIRE RETARDANT
1964	106	N.A.	2	N.A.
1965	226	N.A.	2	N.A.
1966	269	N.A.	3	N.A.
1967	232	214031	3	11.0
1968	212	200281	3	4.3
1969	220	203487	3	12.5
1970	207	191723	3	20.8
1971	161	135021	3	28.0
1972	168	148509	3	47.8
1973	125	105128	3	40.0

N.A. not applicable since no flame retardant research results were presented.

Value formula is: Attendance x meeting days x $25 per diem + one way mileage x 2 + $84.22 x meeting days x attendance = total value x percent of program relating to fire retardants = value attributable to the fire retardant program.

VALUE OF TECHNICAL PRESENTATIONS AT THE FIRE RETARDANT COTTON BATTING WORKSHOP, NOVEMBER 15, 1968

		DOLLAR RATE PER MILE OR DAY DOLLARS	TOTAL VALUE
MILES TRAVELED	389,454	0.15	58,418.10
MAN DAYS SALARY	213	84.22	17,938.86
MAN DAYS, PER DIEM	213	25.00	5,325.00
TOTAL	---	---	81,681.96
ATTRIBUTABLE TO BEDDING FLAME RETARDANT PROGRAM,	23.5%		19,195.26

FACTORS FOR COMPUTING THE VALUE OF TECHNICAL PRESENTATIONS AT THE ANNUAL OILSEED PROCESSING CLINIC, SRRC, 1964-1973

	MILES	MAN DAYS	PERCENT ATTRIBUTABLE TO FLAME RETARDANT PROGRAM
1964	81,614	158	0.0
1965	124,678	228	0.0
1966	91,160	168	7.7
1967	107,286	196	0.0
1968	113,818	186	0.0
1969	130,366	198	5.6
1970	108,188	216	5.3
1971	118,248	220	0.0
1972	79,038	140	7.7
1973	108,076	208	8.3

Value formula is: $25 per diem x mandays in attendance + miles x 15 cents + mandays in attendance x $84.22 = total value x percent of program relating to fire retardants = value attributable to the fire retardant program.

VALUE OF TECHNICAL PRESENTATIONS AT THE CONFERENCE OF COLLABORATORS FROM SOUTHERN AGRICULTURAL EXPERIMENT STATIONS, 1969 AND 1972

		DOLLAR RATE PER MILE OR DAY DOLLAR	TOTAL VALUE DOLLARS
MILES TRAVELED	161,057	0.15	24,158.55
MAN DAYS SALARY	280	84.22	23,581.60
MAN DAYS PER DIEM	280	25.00	7,000.00
TOTAL	---	---	54,740.15
ATTRIBUTABLE TO FLAME RETARDANT PROGRAM 4% 1972, 11.8% 1969			3,441.50

VALUE OF TECHNICAL PRESENTATIONS AT THE ANNUAL OILSEED PROCESSING CLINIC
SRRC, 1964-1973

	PER DIEM DOLLARS	MILEAGE DOLLARS	SALARY DOLLARS	TOTAL DOLLARS	VALUE ATTRIBUTABLE TO FLAME RETARDANT PROGRAM	
					PERCENT	DOLLARS
1964	3,950.00	12,242.10	13,306.76	29,498.86	0.0	0.00
1965	5,700.00	18,701.70	19,202.16	43,603.86	0.0	0.00
1966	4,200.00	13,674.00	14,148.96	32,022.96	7.7	2,465.77
1967	4,900.00	16,090.20	16,507.12	37,497.32	0.0	0.00
1968	4,650.00	17,072.70	15,664.92	37,387.62	0.0	0.00
1969	4,950.00	19,554.90	16,675.56	41,180.46	5.6	2,306.11
1970	5,400.00	16,228.20	18,191.52	39.819.72	5.3	2,110.45
1971	5,500.00	17,737.20	18,528.40	41,765.60	0.0	0.00
1972	3,500.00	11,855.70	11,790.80	27,146.50	7.7	2,090.28
1973	5,200.00	16,211.40	17,517.76	38,929.16	8.3	3,231.12
1964-73	47,950.00	159,368.10	161,533.93	368,852.03	---	12,203.73

NOte: See Appendix Table G-4 for value formula.

5

VALUE OF TECHNICAL PRESENTATIONS AT NON-SRRC SPONSORED CONFERENCES
1964-1973

	NUMBER OF PRESENTATIONS	VALUE/PRESENTATION DOLLARS	TOTAL VALUE DOLLARS
1964	14	3,754.78	52,566.92
1965	2	3,754.78	7,509.56
1966	7	3,754.78	26,283.46
1967	11	3,754.78	41,302.58
1968	12	3,754.78	45,057.36
1969	31	3,754.78	116,398.18
1970	26	3,754.78	97,624.28
1971	22	3,754.78	82,605.16
1972	20	3,754.78	75,095.60
1973	26	3,754.78	97,624.28
1964-1973	171	--------	642,067.38

NOTE: Excludes presentations presented at the Cotton Utilization Conferences, Collaborators of the Southern Agriculture Experiment Stations, Oilseed Processing Clinic and The Cotton Batting Workshops of 1969 and 1972. See Appendix G-8 for the computation formula for the value per presentation.

FACTORS FOR COMPUTING THE VALUE OF TECHNICAL PRESENTATIONS AT NON-SRRC SPONSORED MEETING, CONFERENCES, AND SEMINARS

CONFERENCE/WORKSHOP	TOTAL PRESENTATIONS	VALUE OF CONFERENCES OR WORKSHOPS DOLLARS
Oilseed Processing Clinic, 1963-73	166	368.852.03
Cotton Batting Workshops, 1968	15	81,681.95
Collaborators of Southern Agricultural Experiment Stations, 1969, 1972	43	54,740.15
Cotton Utilization, 1967-1973	166	959,902.22
Total	390	1,464.366.35
Value/Presentation	---	3,754.78

NOTE: It is assumed the value of presentations at non-SRRC sponsored conferences is equivalent to the value of presentations at SRRC sponsored conferences. Total presentations include those given by SRRC and non-SRRC personnel at the respective SRRC sponsored conferences.

VALUE OF NATIONAL COTTON BATTING INSTITUTE AND DIRECTORS OF RESEARCH COMMITTEE MEETING, SRRC, 1970, 1971 AND 1973

		RATE/MILE OR DAY DOLLARS	VALUE OF FIRE RETARDANCE BEDDING PROGRAM DOLLARS
MILEAGE	293,576	0.15	44,036.40
MAN DAYS SALARY	147	84.22	12,380.34
MAN DAYS, PER DIEM	147	25.00	3,675.00
TOTAL	---	-----	60,091.74

Note: These meetings were held at SRRC and were exclusively coordinated by the fire retardant research staff. Therefore, total value was attributed to the fire retardant bedding program.

VALUE OF IN-PLANT TECHNICAL CONSULTATION TEXTILE FIRE RETARDANT PROGRAM, SRRC, 1964-1973

	MAN DAYS OF CONSULTATION	VALUE DOLLARS
1964	17	7,584.55
1965	--	---
1966	15	6,692.25
1967	46	20,522.90
1968	45	20,076.75
1969	22	9,815.30
1970	52	23,199.80
1971	70	31,230.50
1972	60	26,769.00
1973	32	14,276.80
1964-73	359	160,167.85

NOTE: Value for in-plant consultation is equivalent to value of SRRC visitor consultation, $446.15 per visitor.

See Appendix G-11 and G-12 for breakdown on fabric and bedding.

VALUE OF IN-PLANT TECHNICAL CONSULTATION, FABRIC FIRE RETARDANT PROGRAM, SRRC, 1964-1973

	MAN DAYS OF CONSULTATION	VALUE DOLLARS
1964	17	7,584.55
1965	--	--------
1966	15	6,692.25
1967	46	20,522.90
1968	45	20,076.75
1969	11	4,907.65
1970	21	9,369.15
1971	56	24,984.40
1972	46	20,522.90
1973	6	2,676.90
1964-73	263	117,337.45

NOTE: Value for in-plant consultation is equivalent to value of SRRC visitor consultation, $446.15 per visitor.

VALUE OF IN-PLANT TECHNICAL CONSULTATIONS, FIRE RETARDANT BEDDING PROGRAM, SRRC, 1969-1973

	NUMBER OF CONSULTATIONS	VALUE/ CONSULTATION DOLLARS	TOTAL VALUE
1969	11	446.15	4,907.65
1970	31	446.15	13,830.65
1971	14	446.15	6,246.10
1972	14	446.15	6,246.10
1973	26	446.15	11,599.90
1969-73	96	------	42,830.40

VALUE OF VISITOR CONSULTATION WITH TEXTILE FIRE RETARDANT PROGRAM PERSONNEL, SRRC, 1965-1973

	MILEAGE DOLLARS	SALARY DOLLARS	PER DIEM DOLLARS	TOTAL VALUE DOLLARS
1965	233.70	84.22	25.00	342.92
1966	202.80	84.22	25.00	312.02
1967	5,235.60	1,684.40	500.00	7,420.00
1968	8,921.40	1,600.18	475.00	10,996.58
1969	2,182.80	1,010.64	300.00	3,493.44
1970	6,920.70	2,105.50	625.00	9,651.20
1971	18,292.50	3,789.90	1,125.00	23,207.40
1972	4,884.60	1,937.06	575.00	7,396.66
1973	19,500.90	4,295.22	1,275.00	25,071.12
TOTAL	66,375.00	16,591.34	4,925.00	87,891.34

NOTE: Mileage and number of visitors are shown in Appendix Tables G-14 and G-15. Value formula is: mileage x 15 cents + mandyas consultation x $84.22 + mandyas consultation x $25 per diem = total value. Total value ÷ number of visitors = value per visitor.

FACTORS FOR COMPUTING VALUE OF VISITOR CONSULTATIONS
FABRIC FIRE RETARDANT PERSONNEL, SRRC, 1965-1973

	MILEAGE	MAN DAYS
1965	1,558	1
1966	-----	-
1967	12,364	7
1968	39,708	9
1969	8,140	4
1970	3,116	2
1971	95,000	25
1972	24,472	17
1973	109,206	41
TOTAL	293,564	106

FACTORS FOR COMPUTING VALUE OF VISITOR CONSULTATION,
FIRE RETARDANT BEDDING PROGRAM, 1966-1974

	MILES TRAVELED	MAN DAYS
1966	1,352	1
1967	22,540	13
1968	19,768	10
1969	6,412	8
1970	43,022	23
1971	26,950	20
1972	8,092	6
1973	20,800	10
TOTAL	148,936	91

VALUE OF TECHNICAL CONSULTATION BY LETTER AND TELEPHONE FIRE RETARDANT PROGRAM AREA, SRRC, 1964-1973

	VALUE OF LETTERS	VALUE OF TELEPHONE CONVERSATION
1964	3.31	[illegible]
1965	3.31	5.93
1966	6.62	5.93
1967	251.55	195.69
1968	681.86	308.36
1969	592.49	638.58
1970	810.95	1,340.18
1971	403.82	1,120.77
1972	662.00	1,363,90
1973	556.08	1,595.17
TOTAL	3,971.99	6,574.51

NOTE: Value of letter $3.31 and $5.93 for a 15 minute telephone call averaging 926-1360 miles, see Appendix Tables G-17 to 20 for computation factors.

TECHNICAL CONSULTATIONS BY LETTERS AND TELEPHONE CONVERSATIONS, FABRIC FIRE RETARDANT PROGRAM, SRRC, 1967-1973

	LETTERS NUMBER	TELEPHONES
1967	38	10
1968	113	9
1969	106	66
1970	130	122
1971	43	121
1972	133	185
1973	90	195
TOTAL	653	708

VALUE OF TECHNICAL CONSULTATION BY LETTER AND TELEPHONE, FIRE RETARDANT BEDDING PROGRAM, SRRC, 1963-1973

	LETTERS		TELEPHONE CONSULTATIONS	
	NUMBER	VALUE/DOLS.	NUMBER	VALUE/DOLS.
1964	1	3.31	0	---
1965	1	3.31	1	5.93
1966	2	6.62	1	5.93
1967	38	125.77	23	136.39
1968	93	307.83	43	254.99
1969	73	241.63	40	237.20
1970	115	380.65	104	616.72
1971	79	261.49	68	403.24
1972	67	221.77	45	266.85
1973	78	258.18	74	438.82
TOTAL	553	1,830.43	400	2,372.00

COST OF PREPARING A BUSINESS LETTER

	DOLLARS
1964	2.32
1968	2.54
1969	2.74
1970	3.05
1971	3.19
1972	3.20
1973	3.31

NOTE: COST FROM DICTATION TO MAILING

SOURCE: NATION'S BUSINESS, VOL. 61,
NO. 2, PAGE 10, FEB. 1973.

COST OF TELEPHONE COMMUNICATION

MINUTES[1]	3	4	5	8	12	15
56-70 miles	$ .55	$ .71	$ .87	$1.35	$1.99	$2.47
101-124 miles	.70	.90	1.10	1.70	2.50	3.10
197-244 miles	.80	1.04	1.28	2.00	2.96	3.68
355-430 miles	.95	1.24	1.53	2.40	3.56	4.43
926-1360 miles	1.25	1.64	2.03	3.20	4.76	5.93
1911-3000 miles	1.45	1.91	2.37	3.75	5.59	6.97

[1]Dial station-to-station, Monday through Friday, 8 a.m. to 5 p.m.

SOURCE: The Office, Vol. 78, p. 100, November 1973.

NUMBER OF TOURS AND VALUE, SRRC, 1964-1973

	NUMBER		VALUE/ ATTENDEE DOLLARS	TOTAL VALUE DOLLARS	VALUE ATTRIBUTED TO THE FLAME RETARDANT PROGRAM AREA/DOLLARS
	TOURS	ATTENDEES			
1964	54	1048	2.69	2819.12	0.28
1965	94	1465	2.99	4380.35	0.44
1966	78	1051	3.16	3321.16	65.76
1967	77	1212	3.66	4435.92	129.97
1968	76	1199	3.87	4640.13	263.09
1969	71	1186	4.53	5372.58	275.61
1970	90	1239	4.78	5922.42	422.86
1971	92	1098	5.19	5698.62	643.37
1972	79	1184	5.70	6748.80	1033.24
1973	66	1002	6.18	6192.36	844.64
TOTAL 1964-72	777	11684	-----	49531.46	3679.26

Note: See Appendix Table G-22 for computation of the value per attendee. The value attributed to the flame retardant program is the total value x the percent of SRRC resources allocated to the the fire retardant program.

CURRENT EXPENDITURES FOR PUBLIC DAY SCHOOLS
ALLOCATED TO PUPIL COST

YEAR	PER PUPIL IN ADA[1] DOLLARS	COST PER DAY[2] DOLLARS
1964-65	484.00	2.69
1965-66	537.35	2.99
1966-67	569.00	3.16
1967-68	658.26	3.66
1968-69	696.00	3.87
1969-70	815.98	4.53
1970-71	860.00	4.78
1971-72	934.00	5.19
1972-73	1026.00	5.70
1973-74[3]	1112.00	6.18

1/ Frankel, Martin M. and J. Fred Beamer. Projections of Educational Statistics to 1982-83, 1973 edition, DHEW Pub. No. (OE) 74-11105.

2/ Computed on a 180 day attendance.

3/ Preliminary.

NUMBER OF CASES AND DISTRIBUTION BY PATIENT DISPOSITION, NIGHTWEAR AND BEDDING AS FIRST FABRIC INVOLVED IN FIRE INCIDENTS

	NUMBER CASES		PERCENT	
	SLEEPWEAR	BEDDING	SLEEPWEAR	BEDDING
NO INJURY	---	10	---	26.2
NO TREATMENT	---	--	---	----
FIRST AID ONLY	---	--	---	----
TREATED AND RELEASED	21	12	22.8	31.6
ADMITTED	61	12	66.3	31.6
EXPIRED	7	2	7.6	5.3
DOA	1	--	1.1	----
OTHER	---	--	---	----
UNKNOWN	2	2	2.2	5.3
TOTAL	92	38	100.0	100.0

NOTE: BASED ON CASES IN WHICH NIGHTWEAR AND BEDDING WAS THE FIRST TEXTILE MATERIAL TO IGNITE, 1966-1971. PERCENT CALCULATED.

SOURCE: FLAMMABLE FABRICS, THIRD ANNUAL REPORT, DHEW PUB. (FDA) 72-7013.

CALCULATED DISTRIBUTION OF PATIENTS IN WHICH NIGHTGOWNS, PAJAMAS AND MATTRESSES WERE FIRST FABRICS INVOLVED, 1966-1973[1/]

	NIGHTGOWNS & PAJAMAS 0-6X	BEDDING	TOTAL CASES
NO INJURY	----	43.8	43.8
NO TREATMENT	----	----	----
FIRST AID ONLY	----	----	----
TREATED AND RELEASED	18.5	52.7	71.2
ADMITTED	53.7	52.7	106.4
EXPIRED	6.1	8.9	15.0
DOA	.9	----	0.9
UNKNOWN	1.8	8.9	10.7
TOTAL, CASES	81.0	167.0	248.0

1/ CALCULATED FROM DATA IN B-10 AND THE DISTRIBUTION SHOWN IN TABLE G-23. DATA ROUNDED.

Example of Negative Data

Chairman's Address

Duane L. Larson, M.D., F.A.C.S.

Director
University of Texas Burn Unit

Chief of Staff
Shriners Burns Institute

Galveston, Texas 77550

As chairman of the Council, I extend to all a warm welcome to the Eighth Annual meeting of the Information Council on Fabric Flammability, one of the most stimulating, influential, and unique groups I have had the pleasure to be associated with. The New York Academy of Medicine Conference on fabric flammability in 1966 resulted in the formation of the Information Council on Fabric Flammability in 1967. This national group consists of representatives from many segments of the textile industry, governmental agencies, voluntary health and safety organizations, and medical and legal groups. Its purpose is "to work for the reduction of morbidity and mortality from burns caused by flammable fabrics and related materials."

A number of questions frequently arise concerning this Council. Is the burn problem in our country sufficient to warrant a Council? Has the Council during its seven year history made any progress in this difficult area? The answer to the first question is yes. Over one million Americans suffer from burns annually and six thousand hospital beds continually hold patients with thermal injuries; twelve thousand of these patients expire annually. When clothing is involved the burns cover twice as much body surface,

six times as much skin is a deep burn (full thickness), and the death rate is four times greater than those accidents where clothing was not involved. The morbidity, however, is much greater for most of these patients develop severe sequelae following thermal injury. These sequelae have been described beginning on page 86 of the Proceedings of the Fifth Annual Meeting of the Information Council on Fabric Flammability. The sequelae described consisted of edema formation, shock, pain, loss of extremity, loss of eyes, ears, or nose, lung damage, bleeding stomach ulcers, joint damage, scar production, crippling deformities, and finally severe emotional disturbances. The frequency of burns, and the mortality are sufficient to necessitate this Council. The morbidity alone, however, is more than sufficient to warrant this group. These patients face a nightmare of painful procedures and fear of death. Upon discharge, they are faced with a slow and very difficult uphill recovery period. Numerous plastic surgical procedures performed over many years may be necessary. Upon completion both the patient and his surgeon are frustrated and disappointed for the patient will never again regain his previous appearance, he is scarred for life.

The answer to the second question is also an emphatic yes. I know that the beginning stimulus for Texas to pass flame retardant legislation came from this Council. The Texas members by working with this Council were aware of the overall current status of the burn problem, what was required, and what was technically possible. Many of our textile members were most helpful in our endeavor and met frequently in the Shrine Burns Institute in Galveston. I am also certain the national legislation and technical advances

Duane L. Larson, M.D., F.A.C.S.

made owe their origin to this Council. The flame retardant clothing has brought a wonderful new era to our country. Those patients wearing flame retardant clothing are receiving relatively minor injuries. The clothing which previously was so hazardous that a match could result in an 80% to 90% burn is now protective. (Fig 1 & 2) Some examples will be described. A five year old girl was trapped in a burning house from a Christmas tree fire, flamming wall paper fell on the right side of her body. She received a small burn on her right hand and arm because she had the sleeve of her flame retardant pajamas rolled up to the elbow. (Fig 3) A six year old boy was trapped in a burning pick-up truck that had crashed. When he was removed from the truck his pajamas were blackened, but he received only second degree burns and soon recovered. (Fig 4) An eight year old girl had her flammable robe burned off, however, she received only second degree burns due to the protective effect of the flame retardant pajamas worn beneath the robe. This was also true when an elderly woman simultaneously was protected from the burning robe by flame retardant night gown.

All of the members of this council have worked long and hard to develop flame retardant protection for our children to prevent the ravages of burn injuries to our youth. We physicians are seeing the fruits of your labor and I bring to you on behalf of these children their heartfelt thanks. May the Supreme Architect of the universe bless each and everyone of you.

SOURCE: Proceedings of the Eight Annual Meeting of the Information Council on Fabric Flammability, New York, December 5, 1974.

ESTIMATED VOLUME AND COST OF CHEMICALS REQUIRED FOR FIRE RETARDANT TREATMENT OF TEXTILE FABRIC AND SMOLDER RESISTANT PRODUCTS

Thpc-Amide Fire Retardants System

CHEMICAL	TOTAL LBS. MIL.	P/POUND CENTS	TOTAL COST DOLLARS
Thpc	3.12	100.00	3,120,000
Urea	3.90	8.38	365,040
Trimethylolmelamine	3.51	50.00	1,755,000
NaOH	0.65	7.64	49,660
Auxiliaries	0.65	32.50	211,250
	11.83 (A)		5,500,950

THPOH-NH_3 FIRE RETARDANT SYSTEM

Thpc	3.12	100.00	3,120,000
NaOH	0.52	7.64	29,728
H_2O_2	0.55	13.75	75,625
NH_4OH	0.06	8.63	5,178
Softener & wetting agent	0.003	32.50	975
	4.25 (B)		3,231,503
Subtotal (A and B)	16.08	-----	8,732,456
Batting	2.10	6.90	144,900
Grand Total	18.18	-----	8,877,356

1/ Thpc production capacity is estimated at 5 to 7.5 million pounds or an average of 6.25 million pounds. This is used as a basis for Thpc-amide and THPOH-NH_3 fire retardant systems. It is estimated that approximated 1/2 of the Thpc is used equally for each of the above fire retardant systems.

COMPUTATION FACTORS USED TO DERIVE THE VALUE OF FIRE RETARDANT COTTON BATTING

MACHINERY AND CHEMICAL USE

35 APPLICATORS, $2700 EACH, INCLUDING IN-PLANT INSTALLATION, $94,500

250 DAYS OPERATION

1-8 HOUR SHIFT/DAY

300 LBS. TREATED/DAY

TOTAL HOURS APPLICATORS USED 2,000 (8 x 250)

TOTAL APPLICATOR HOURS 70,000 (35 x 2000)

LINTERS USED 21 MIL. LBS. (70,000 x 300)

COST OF LINTERS $1,877,400 (21 MIL. x 8.94)

30 LBS. RETARDANTS/HOUR/APPLICATOR

TOTAL BORIC ACID 2.1 MIL. LBS. (70,000 x 30)

PRICE/LB. OF BORIC ACID, 1973 6.9¢

TOTAL BORIC ACID COST $144,900 (2.1 MIL.LBS. x 6.9¢)

TOTAL AND COTTON MATERIALS USED IN THE PRODUCTION OF CHILDREN'S SLEEPWEAR SIZES 0-6X

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
KNIT NIGHTGOWNS										
TOTAL MATERIALS										
SQ. YDS.,1000	----	----	12714	12627	17047	17083	17506	16108	13479	12747
LBS.,1000	----	----	3512	3488	4709	4719	4836	4478	3710	3518
480 LB. BALES	----	----	7763	7707	10829	10431	10690	11651	9550	9060
COTTON MATERIALS										
SQ. YDS., 1000	----	----	6275	6143	7979	7470	7491	11955	8606	383
LBS., 1000	----	----	2946	2884	3746	3507	3517	3331	6380	106
480 LB. BALES	----	----	6508	6371	8280	7758	7774	8680	6160	270
KNIT PAJAMAS										
TOTAL MATERIALS										
SQ. YDS., 1000	70113	62703	60788	60255	53418	63202	63165	66444	66571	55076
LBS., 1000	24601	22001	21329	21142	18743	22176	22163	24046	23885	18082
480 LB. BALES	54384	48635	47142	46730	41423	49663	49040	54510	54160	41050
COTTON MATERIALS										
SQ. YDS., 1000	62624	54965	51679	49688	43640	49663	48442	47431	42707	1981
LBS., 1000	22207	19491	18326	17620	15475	17611	17178	16918	15102	664
480 LB. BALES	49087	43087	40502	38945	34072	38918	37970	38380	34270	1500
WOVEN NIGHTGOWNS										
TOTAL MATERIALS										
SQ. YDS., 1000	8501	8568	11177	10759	11159	8386	8552	10184	15033	9481
LBS., 1000	2015	2031	1971	1892	1994	1584	1616	2556	3144	1917
480 LB. BALES	4375	4404	4220	4053	4275	3407	3469	5940	7310	4460
COTTON MATERIALS										
SQ. YDS., 1000	8076	8054	10340	9755	9535	7079	7016	9695	11422	1043
LBS., 1000	1914	1909	1834	1727	1720	1351	1338	2035	2390	211
480 LB. BALES	4154	4144	4078	3696	3788	2905	2880	4730	5750	490

TOTAL AND COTTON MATERIALS USED IN THE PRODUCTION OF CHILDREN'S SLEEPWEAR SIZES 0-6X

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
WOVEN PAJAMAS										
TOTAL MATERIALS										
SQ. YDS., 1000	24606	26221	30587	16519	21256	12475	12175	14331	12732	10501
LBS., 1000	5832	6214	2948	2822	2946	2404	2344	3073	2729	2181
480 LB. BALES	12654	13490	6916	6085	6294	5171	5044	7080	6290	5020
COTTON MATERIALS										
SQ. YDS., 1000	23868	24910	16242	15292	15277	10851	10364	11931	10217	2205
LBS., 1000	5657	5903	2789	2619	2611	2108	2007	2553	2190	458
480, LB. BALES	12279	12817	4847	5598	5577	4533	4320	5900	5050	1060
TOTAL NIGHTWEAR										
TOTAL MATERIALS										
SQ. YDS., 1000	103220	97492	115266	100160	102880	101146	101398	107067	107815	87805
LBS., 1000	32448	30246	29329	29344	28392	30883	30959	34153	33468	25698
480 LB. BALES	71413	66529	62073	64575	62821	68672	68243	79181	77310	59590
COTTON MATERIALS										
SQ. YDS., 1000	94568	87929	84536	80878	76431	75063	73313	81012	72952	5612
LBS., 1000	29778	27303	25895	24850	23552	24577	24040	24837	26062	1439
480 LB. BALES	65520	60048	55935	54610	51717	54114	52944	57690	51230	3320

SOURCE: Based on NCC data in Cotton Counts Its Customer.

Estimated U.S. Consumption of Mattress Felts, Padding and Cushioning Materials in the Bedding, Automotive, and Furniture Industries, 1962-1972 (All Materials Expressed in Cotton Batting Equivalent Poundage)

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
	- - - - - - - - - - - - - - - - - - MILLIONS OF POUNDS - - - - - - - - - - - - - - - - - -											
Consumption of All Materials in Batting Equivalents, Total	808	848	871	982	969	909	941	930	877		800	
Bedding	387	392	397	433	442	438	434	436	443		322	
Automotive	229	252	256	299	275	237	274	255	207		228	
Furniture	192	204	218	250	252	234	233	239	227		250	
Cotton Batting, Total	552	555	558	620	613	574	593	575	505		337	
Bedding	343	337	344	370	381	374	374	374	377		249	
Automotive	153	161	155	187	172	148	168	148	83		43	
Furniture	56	57	59	63	60	52	51	53	45		45	
Other Materials, Total	256	293	313	362	356	335	348	355	372		464	
Bedding	44	55	53	63	61	64	60	62	66		73	
Automotive	76	91	101	112	103	89	106	107	124		186	
Furniture	136	147	159	187	192	182	182	186	182		205	

PRICE PER POUND FOR GRADE 2 STAPLE 2 COTTON LINTERS, 1973

MONTH	¢/LB.
JANUARY	6.50
FEBRUARY	6.69
MARCH	7.00
APRIL	7.19
MAY	7.75
JUNE	8.06
JULY	8.44
AUGUST	9.31
SEPTEMBER	10.75
OCTOBER	11.38
NOVEMBER	12.00
DECEMBER	12.25
AVERAGE	8.94

SOURCE: Monthly Cotton Linter Review, AMS, USDA.

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APPENDIX H

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